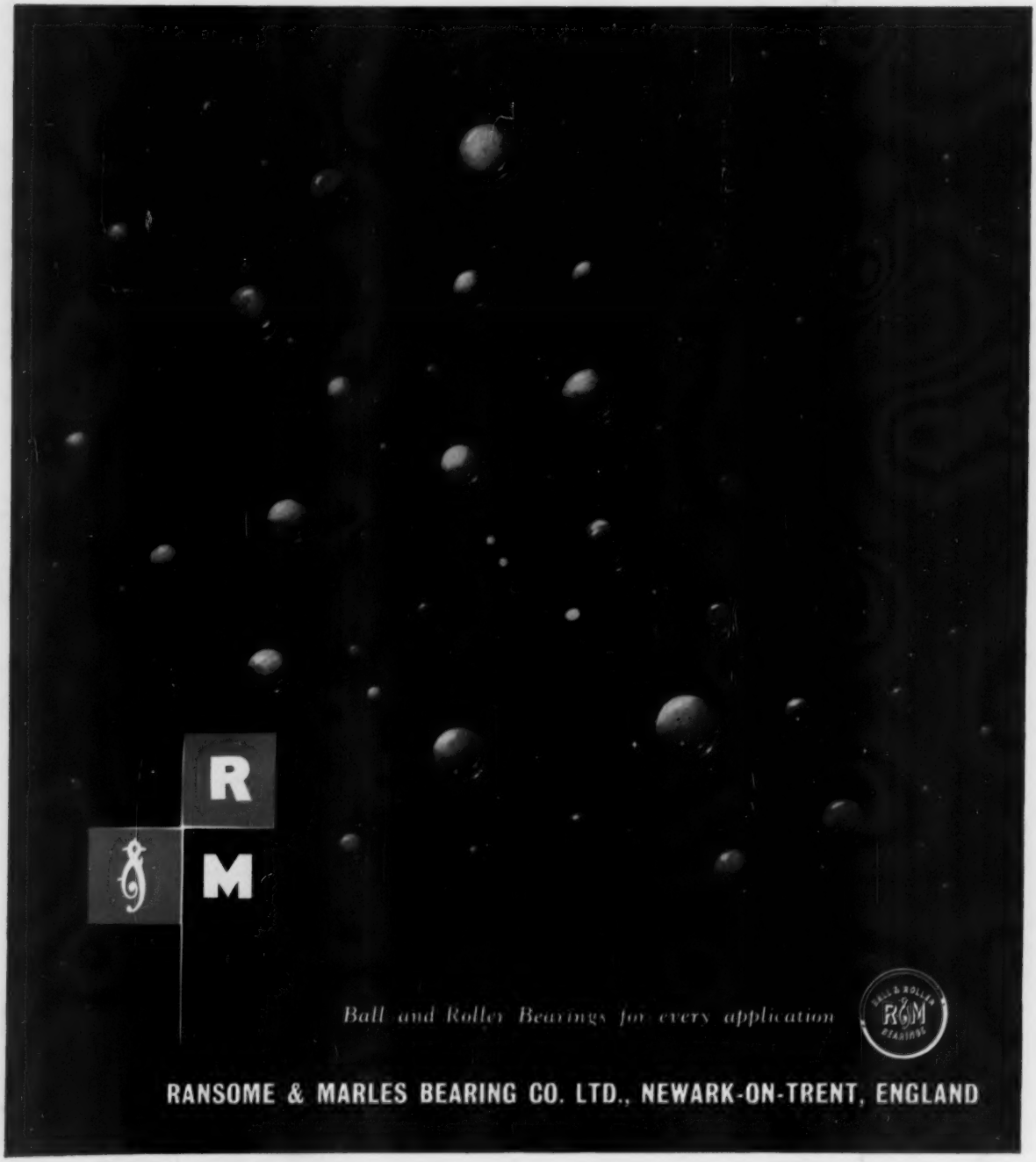
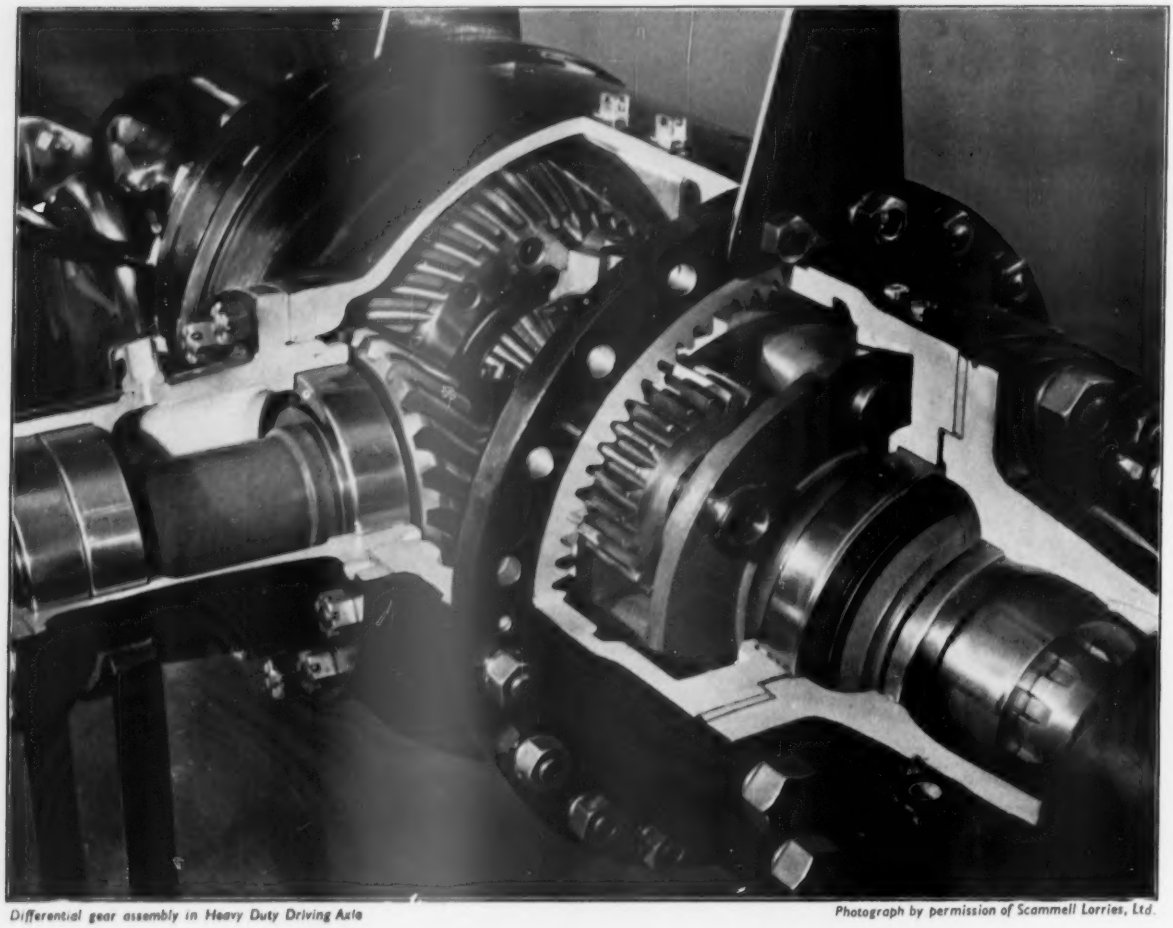
AUTOMOBILE ENGINEER

DESIGN · PRODUCTION MATERIALS

Vol. 45 No. 5 MAY 1955 PRICE: 3s. 6d.



High Quality DROP FORGINGS



Differential gear assembly in Heavy Duty Driving Axle

Photograph by permission of Scammell Lorries, Ltd.

for the automobile and transport industries

by

FIRTH-DERIHON

THE FIRTH-DERIHON STAMPINGS LTD · TINSLEY · SHEFFIELD

R300 TYPE NAXOS-UNION

CYLINDRICAL GRINDING MACHINES

six machines developed from one basic type and unit-built

The R300 series of standard machines, utilising various unit mechanisms in combination, meet a wide variety of production grinding applications in the most economical manner. In addition to these standard types, machines can be supplied with different combinations of mechanisms to meet special conditions.

RG300 PLAIN GRINDER. Basic machine with hand feed to wheel-head and work-table. Suitable for small batch work of simple character.

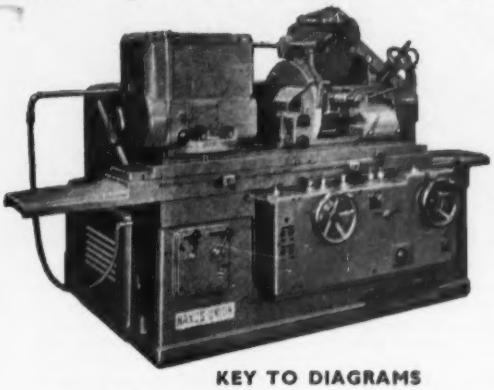
RE300 PLUNGE GRINDING MACHINE. Employs wide or multiple wheels. Hydraulic movement to grinding head with fast approach, fine feed, and fast return. Dual control axial adjustment for grinding to shoulders. Hydraulic tailstock withdrawal.

RM300 CRANKSHAFT LINE BEARING GRINDING MACHINE. Hydraulic table movement for quick indexing from bearing to bearing. Interlocked controls obviate incorrect operation.

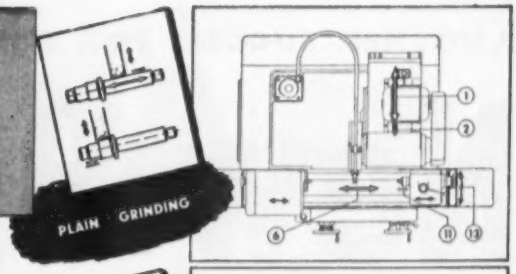
RP300 GENERAL PURPOSE GRINDING MACHINE. Hydraulic grinding head movement and automatic hydraulic table traverse with automatic reversal. Tailstock hydraulically operated.

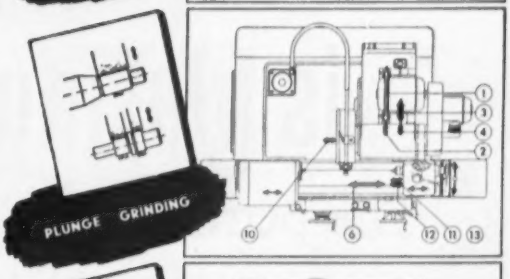
RS300 GENERAL PURPOSE MACHINE WITH SWIVELLING GRINDING HEAD. Fitted with a swivelling grinding head with axial adjustment. Suitable for plunge grinding short length tapers and tangent grinding the sides of collars or faces.

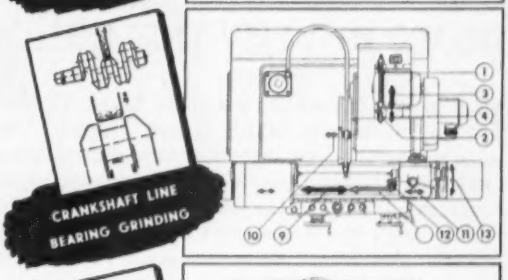
RU300 UNIVERSAL GRINDING MACHINE. In addition to the features of the basic type this model has automatic longitudinal movement of the table, swivelling wheel-head and work-head and internal grinding attachment.

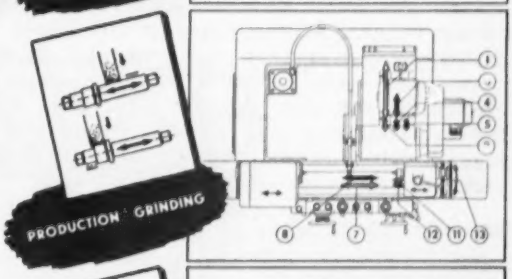


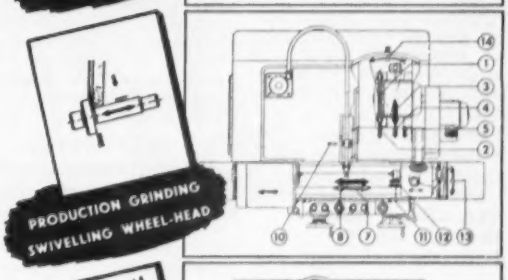
Type RU300 Universal Grinding Machine

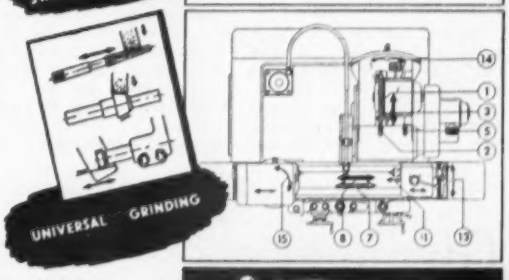












KEY TO DIAGRAMS

BLACK ARROWS Automatic hydraulic movement. **OPEN ARROWS** Hand adjustment. **THIN ARROWS** Possibility of adjustment.

1. Hand movement.
2. Fine adjustment by hand.
3. Hydraulic quick adjustment.
4. Hydraulic plunge-cut motion.
5. Automatic fine adjustment.
6. Hand movement, one speed.
7. Hand movement, two speeds.
8. Hydraulic movement with reversal.
9. Hydraulic fast motion.
10. Axial movement.
11. Return motion by hand.
12. Hydraulic return motion.
13. Can be swivelled.
14. Can be swivelled.
15. Can be swivelled.

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ANOTHER SUCCESS FOR THE BRITISH PETROLEUM COMPANY!

New BP Super

is platinum-processed

The petrol with more energy per gallon

IT IS ONLY a few months since The British Petroleum Company introduced BP Special Energol 'Viscostatic' motor oil — the biggest advance ever made in car lubrication. Now, from this same company, comes a remarkable development in motor spirit, the new BP Super.

This new petrol is the result of a revolutionary new process. Petroleum experts have described this as 'the greatest technical advance since the introduction of catalytic cracking some 15 years previously.' In this process, the spirit is passed through a *catalyst impregnated with pure platinum. The effect is to re-form the petroleum molecules so that the petrol burns more smoothly, gives greater freedom from engine-knock —and has more energy per gallon.

What this means to you

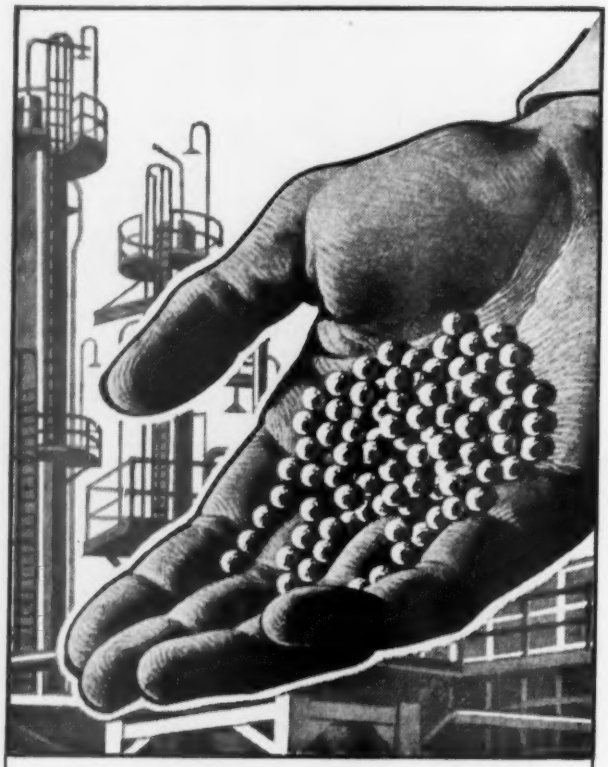
New BP Super gives an *immediate* 'fillip' to your car's performance. And that's not all. Just see what you're going to get when you run on this platinum-processed motor spirit :—

More energy per gallon
Smoother, swifter acceleration
Greater freedom from engine-knock
More miles per gallon
Less engine deposits
Longer engine life

New BP Super suits *all* cars—whether the engine is new or old, o.h.v. or side-valve, high or low-compression. Indeed, because it will suit higher-than-ever compression ratios, new BP Super opens the way to further progress in engine design. But whatever the make and year of your present car, you will find this platinum-processed spirit gives it a new lease of life. You'll get better performance right from the start — and a saving in fuel consumption.

You feel the benefit immediately

You can prove it for yourself, in your own car. Fill your tank with new BP Super and you will enjoy better performance straight-away. What is more, you will enjoy it without paying a penny extra. Another great thing about new BP Super is that it costs no more than ordinary premium-grade petrols produced by less advanced refining methods.



* A catalyst is an agent which assists in producing a chemical change in other substances without being changed itself. In 'platforming', as the platinum-process is called in the oil industry, the spirit is passed through a catalyst impregnated with pure platinum. This is in the shape of pellets — each no bigger than a small pill! The effect is to re-form the petroleum molecules so that new BP Super gives greater freedom from engine-knock and more energy per gallon.

Give *your* car

MORE ENERGY PER GALLON!



THE BP SHIELD IS THE TRADE-MARK OF THE BRITISH PETROLEUM COMPANY LIMITED

Have you seen the new Shell and BP Road Maps? *Produced by George Philips & Son exclusively for Shell and BP Service, these maps show at a glance the type of country on any selected route. The whole of the British Isles is covered in 6 sections, scale 6 miles to the inch. Ask for them at any Shell and BP garage. Price one shilling*

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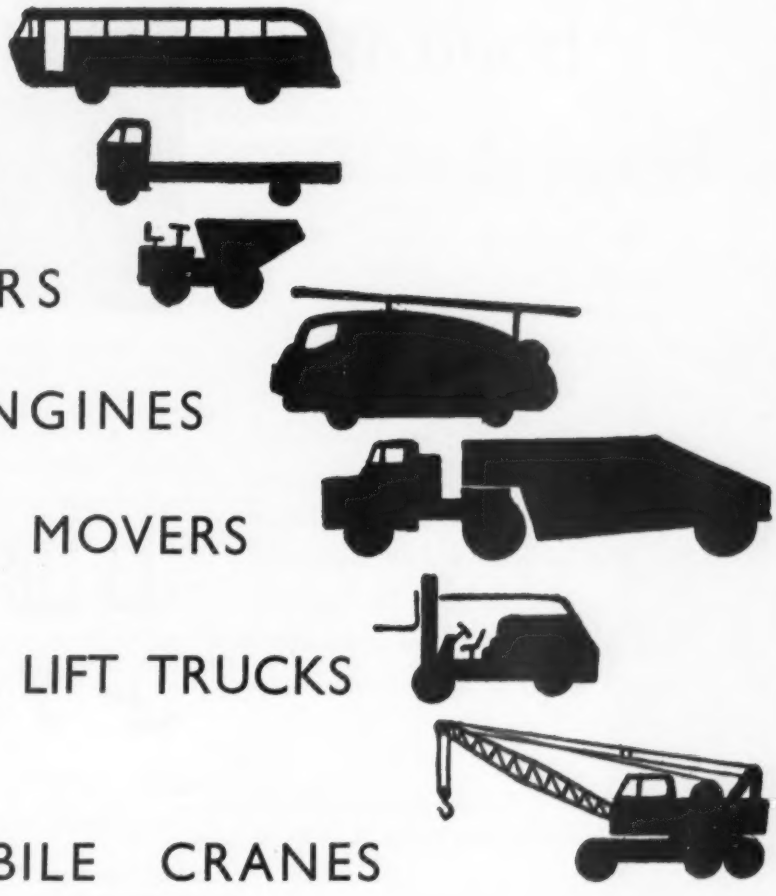
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hood up–
hood down...



David Brown Lagonda Drop-head coupé

. . . this handsome Lagonda drop-head coupé is definitely built for all-weather motoring. Up or down, the hood is one of the outstanding features of this car—because it is in Everflex leathercloth, made with Geon PVC. Through summer sun and winter rain . . this tough yet elegant material will neither crack nor flake . . and will remain completely waterproof, even after years of use. Only an occasional wipe with a damp cloth is needed to keep it always in immaculate showroom condition.

"Everflex" Leathercloth produced by Bernard Wardle (Everflex) Ltd.

GEON PVC

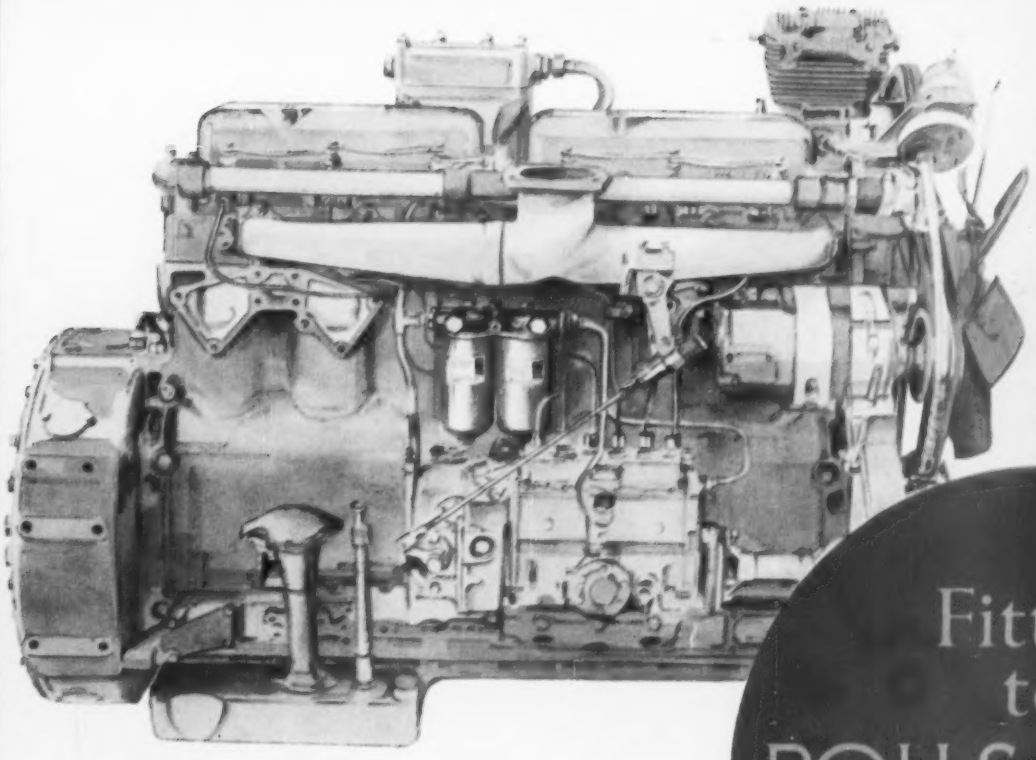
Geon PVC materials are polyvinyl chloride plastics.
Please write for descriptive Booklet No. 116 free on request.

Geon
Polyvinyl Materials

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Fitted to ROLLS-ROYCE oil engines

For diesel fuel

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2. *It is completely water-resistant.*
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There is a Purolator filter for every purpose, lubricating oil, fuel oil, petrol—even for water.

The illustration shows the Rolls-Royce 6-cylinder model C6.SFL. Series 109 supercharged engine, rated at 250 b.h.p. at 2100 r.p.m., fitted with Purolator fuel-oil filters.

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MICRONIC FILTER

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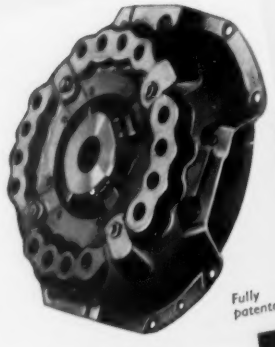
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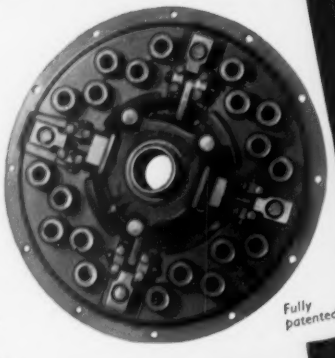
For every type of installation

WITH TORQUE CAPACITIES
FROM 38 TO 1600 LB./FT.



THE 'A' TYPE RANGE OF BORG & BECK SINGLE DRY PLATE CLUTCHES

6½" · 7¼" · 8" · 9" · 10" · 11" · 12" · 13" dia.
38 · 55 · 80 · 130 · 150 · 185 · 210 · 245 lb./ft.



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10" dia. 230 lb./ft.
11½" dia. 350 lb./ft.
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1050 lb./ft.
14" dia. twin plate clutch



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10" clutch with S.A.E. housings Nos. 1, 2, 3, 4.
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Electric melting capacity is made available to the producer of investment castings by the Model IC Detroit furnace. Advantages such as negligible metal loss . . . exceptional metal purity . . . temperature control up to 1750°C . . . absence of smoke and fumes and small overall dimensions can thus be applied to this steadily growing process.

This Model IC Birlec Detroit unit has a molten metal capacity of 10 lb. and its furnace shell has been specially designed to take an investment casting mould. With a rating of only 17 kW, economical operation matches inexpensive first cost.

May we send further details? We should also be pleased to tell you about our other electric melting furnaces: direct arc Birlec Lectromelts up to 150 tons; high frequency and mains frequency induction units, and Birlec Tama low frequency induction furnaces, to be found in increasing numbers in aluminium and zinc casting shops.

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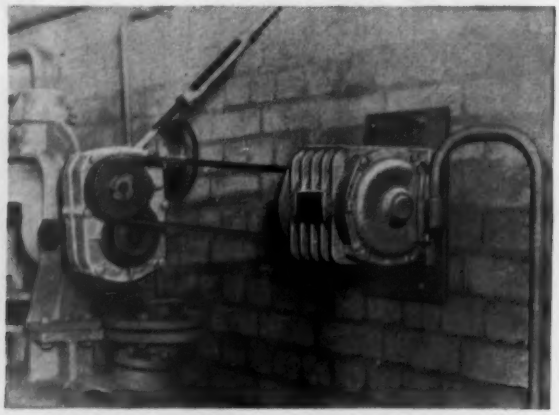
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NOW! SPACE IS NO PROBLEM IN SPEED REDUCTION



THE OLD METHOD.

A nationally famous firm of manufacturing chemists had the problem of driving chemical mixers at 60 r.p.m. A base mounted gear box was impractical and a cumbersome and expensive double reduction overhead drive had to be used.



THE NEW METHOD.

A Torque-Arm shaft mounted speed reducer was installed on top of the mixer driven through a Taper-Lock V-Drive by a wall mounted motor. Advantages: clean safer drive, economy in space, simplified maintenance, more useful power transmitted.



TORQUE-ARM CAN HELP YOU TOO!—

Space limitations no longer prevent you installing a speed reducer. The Fenner Torque-Arm Reducer mounts direct on the driven shaft and can be driven through any V-Belt Drive. It delivers up to 97% of power to output shaft. No motor base or slide rails are required, no flexible couplings needed. It is suitable for the majority of slow speed drives.



TECHNICAL LITERATURE IS AVAILABLE.

Literature giving all the facts about Fenner Torque-Arm Speed Reducers is available . . . send for your copy TODAY. Fenner Technical Advisory Service will be glad to consider your Speed Reduction problems and advise on the suitable application of Torque-Arm Speed Reducers.

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FIRST WITH TORQUE-ARM SHAFT SHAFT MOUNTED *MOUNTED SPEED REDUCERS IN THE U.K.*

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One of our Underdriven Worm Reduction Units fitted to a wool textile machine which we build at our Milnrow works.

We're as pleased as a Manchester man at a Test Match that *hasn't* been rained off. We're taking our own medicine—using our own Worm Units all over our own works. And we're liking it, because these units are doing their various jobs so very well. Which is what you'd expect from the way we make them—on special machines and from special metals, both developed by us during 50 years of Worm Gear manufacture. That's the Holroyd prescription for first-class Worm Units—

MADE UP FOR YOU IN A FEW DAYS

A Standard Type Holroyd Worm Reduction Unit with a stock ratio can be made up, packed and despatched to you within a few days. Special units or worms and wheels made to order take a bit longer. For information on our Worm Units, and on new applications for them (like the machine in the illustration) drop us a line at Milnrow, Lancs. We'll be glad to help you all we can.



Holroyd

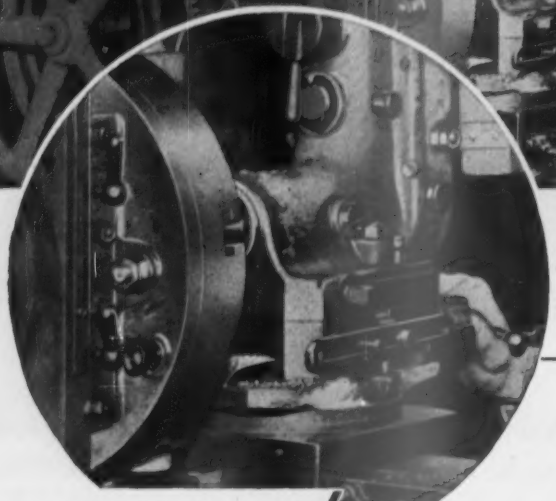
WORM REDUCTION UNITS

BIF 9-13 May CASTLE BROMWICH BIRMINGHAM SEE OUR EXHIBIT

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THIS IS HOW ANGLEPOISE LIGHTS UP THE JOB IN STRONG RELIEF— SAVING EYESTRAIN AND FATIGUE



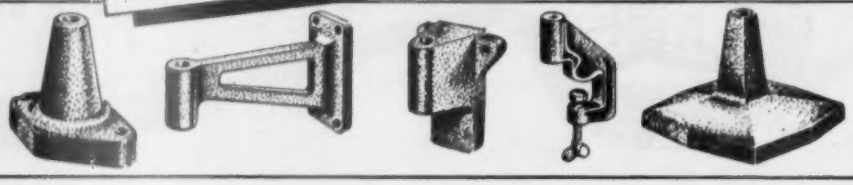
A clever engineer in talking of ANGLEPOISE described it thus. In addition, it's like a third working hand. It follows the work all over the job at a finger touch, throwing its clear concentrated light right on the job from any angle. It ' stays put ' in any position even near heavily vibrating machinery and uses very little current—a 25 or 40 watt bulb will do. Why not learn more about this fine lamp by sending for Booklet A?

Sole Makers: **HERBERT TERRY & SONS LIMITED**
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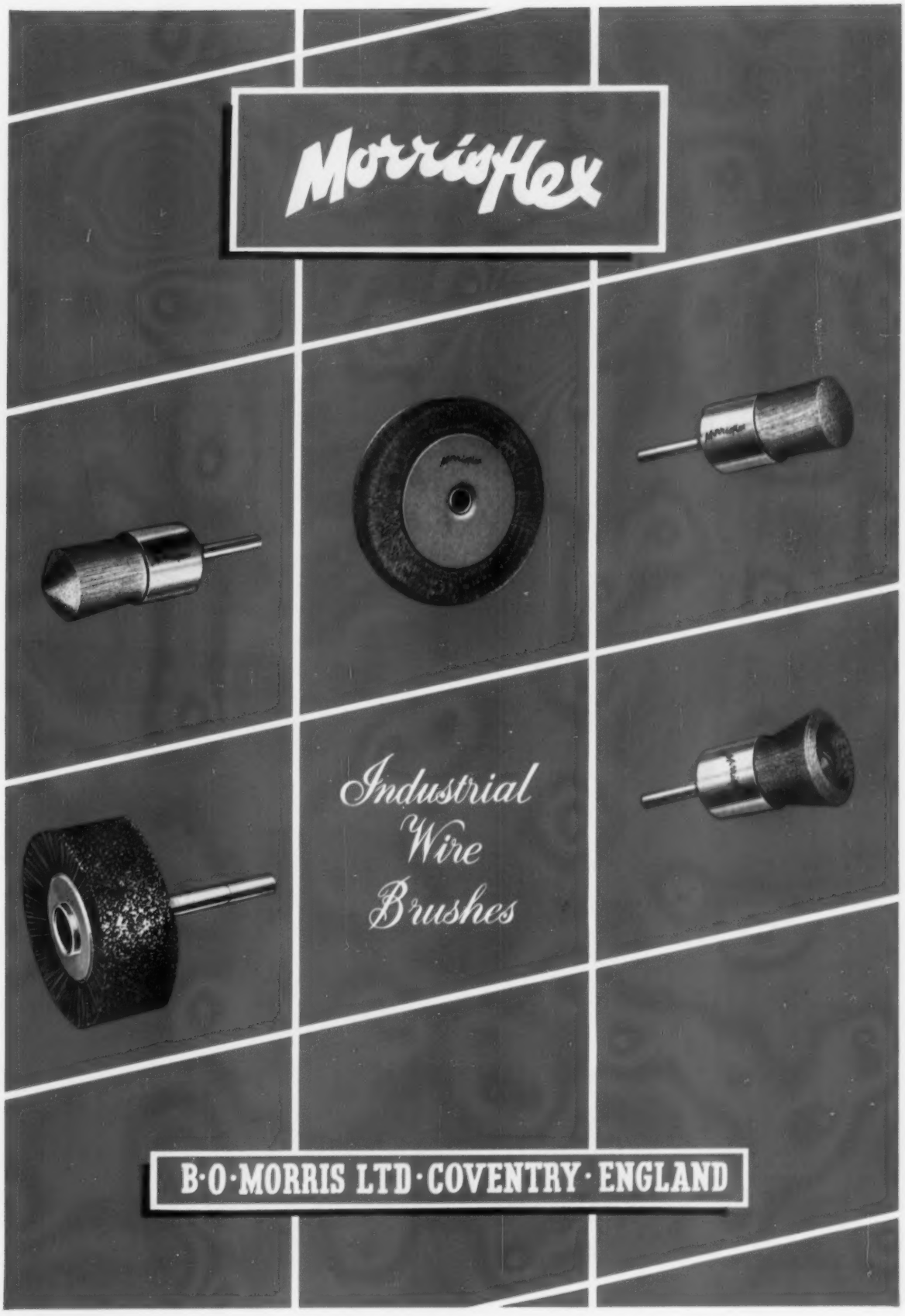
TERRY ANGLEPOISE LAMPS

Pat. all countries

SOME ALTERNATIVE BASES FOR ALL MODELS



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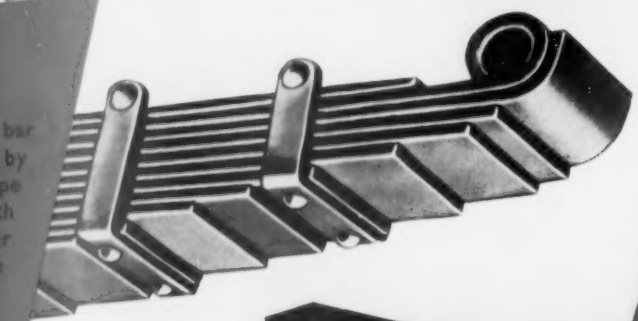


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COIL SPRINGS

Coil, laminated and torsion bar springs are manufactured by Toledo Woodhead for every type of automotive vehicle — with shot blast treatment for longer fatigue life if required. We also supply Tine springs for cultivator and agricultural implement manufacture.



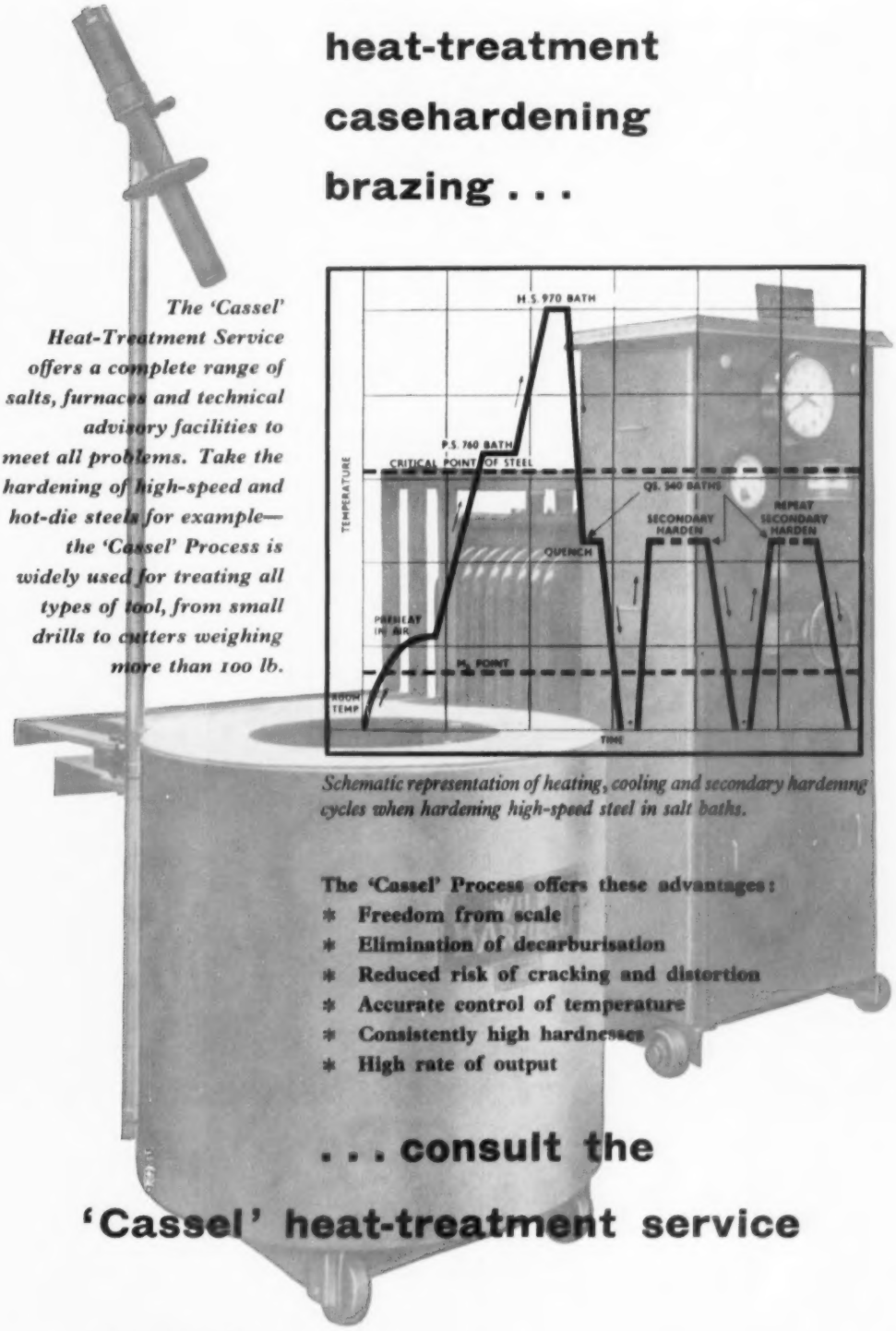
LAMINATED SPRINGS

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TW582

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heat-treatment
casehardening
brazing . . .



The 'Cassel' Heat-Treatment Service offers a complete range of salts, furnaces and technical advisory facilities to meet all problems. Take the hardening of high-speed and hot-die steels for example—the 'Cassel' Process is widely used for treating all types of tool, from small drills to cutters weighing more than 100 lb.

Schematic representation of heating, cooling and secondary hardening cycles when hardening high-speed steel in salt baths.

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* **Freedom from scale**
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* **Accurate control of temperature**
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* **High rate of output**

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'Cassel' heat-treatment service

IMPERIAL CHEMICAL INDUSTRIES LTD.
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Outstanding achievement

*Eighteen months' consistent service— no trouble at all

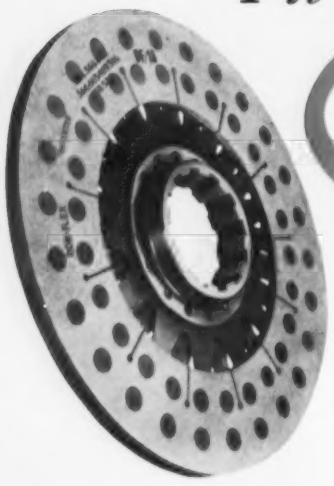


All over the world Don-Flex clutch discs have earned a fine reputation for extra-long, trouble-free service—a well deserved reputation! But that's not all. Their construction and flexibility ensures smooth progressive engagement with no 'judder' at all. And the ingenious design of Don-Flex clutch discs eliminates all clutch drag.

Most makes of cars and commercial vehicles and *particularly those having Diesel engines* can be fitted from stock with Don-Flex clutch discs specially designed for them. Our Depots will advise you which type to fit. We ourselves will be very happy to send you full technical information on request.

*A customer in Malta reports that Don-Flex clutch discs fitted to Perkins Diesel Engines have given no trouble at all since they were fitted eighteen months ago.

Fit a



PATENT NONSCORING FLEXIBLE

Don-Flex

CLUTCH DISC

to be **sure**

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Pollard

Clutch Withdrawal and Water Pump Spindle Bearings



Pollard Bearings Limited

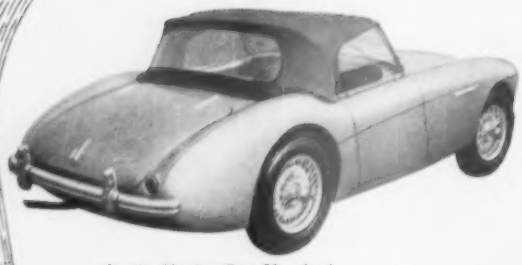
also manufacture Ball, Roller and Thrust bearings (Cat. BRT/1053). Solid and Flexible Roller bearings (Cat RFX) Transmission Equipment and Plummer Blocks (Cat. T.R. 27/2) Self-Lube Plummer Blocks (Cat. SL/54) Automobile and Tractor Replacements (Cat. BRM/54) Clutch Withdrawal Bearings (Cat. CWFP/54). Max Load Roller Bearings (Cat. MOX/55).

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Nash Metropolitan (Manufactured by The Austin Motor Co. Ltd.)



Triumph TR2 Sports.

Visit us on Stand 74 at the British Plastics Exhibition, Olympia, June 1st — 11th.

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All these rear windows *fold* with their hoods, and there's no fear of cracking, crazing or marking with tough VYBAK Flexible Clear Sheet. Larger rear windows mean more light, better vision—and greater safety. Samples and prices gladly sent to manufacturers and accessory dealers.

Each of the States in the U.S.A. has tested and approved VYBAK Clear Sheet, which complies with the American Safety Code for motor vehicles.

VYBAK REGD.

Flexible Clear Sheet

BAKELITE LIMITED · 12-18 GROSVENOR GARDENS · LONDON · S.W.1

V54



Illustration by courtesy of Birmingham Aluminium Castings (1903) Co. Ltd.

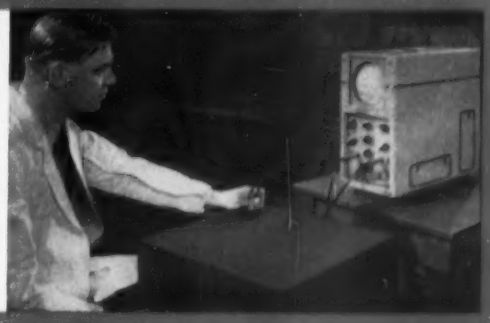
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THERMAL FATIGUE RESISTING STEELS

FOR DIE-CASTING, EXTRUSION, STAMPING & FORGING

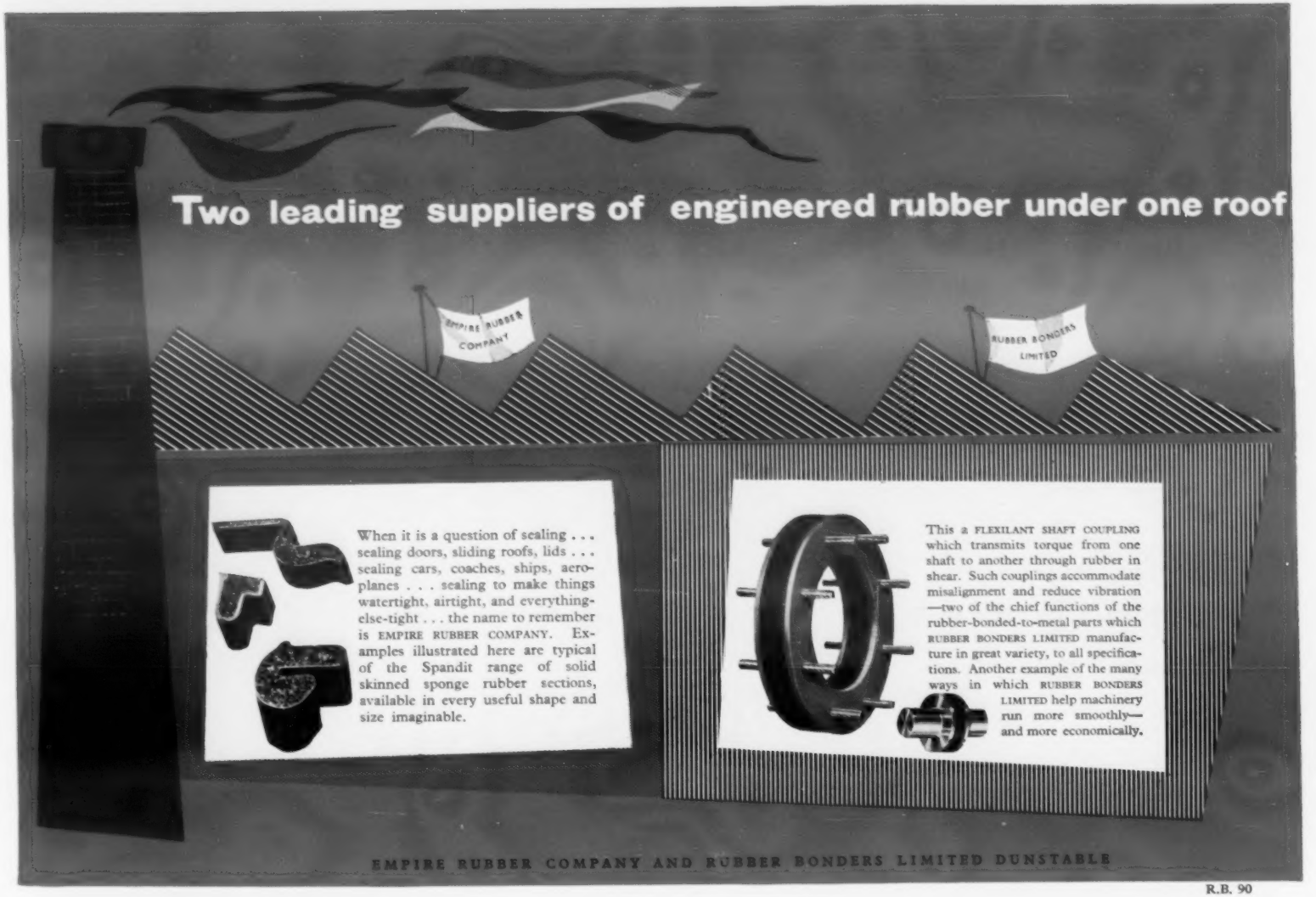
HOT WORKING TOOL STEELS IN ULTRASONICALLY TESTED FORGINGS...

Our recent developments in this field are the result of careful research by our Technical Staff into the call for increased productivity. Should you wish for details of our specialities please notify us so that we may arrange for one of our Technical Representatives to call upon you.



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CARLISLE STEEL WORKS • SHEFFIELD • ESTABLISHED 1825


Two leading suppliers of engineered rubber under one roof
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When it is a question of sealing . . . sealing doors, sliding roofs, lids . . . sealing cars, coaches, ships, aeroplanes . . . sealing to make things watertight, airtight, and everything-else-tight . . . the name to remember is EMPIRE RUBBER COMPANY. Examples illustrated here are typical of the Spandit range of solid skinned sponge rubber sections, available in every useful shape and size imaginable.
This a FLEXILANT SHAFT COUPLING which transmits torque from one shaft to another through rubber in shear. Such couplings accommodate misalignment and reduce vibration —two of the chief functions of the rubber-bonded-to-metal parts which RUBBER BONDERS LIMITED manufacture in great variety, to all specifications. Another example of the many ways in which RUBBER BONDERS LIMITED help machinery run more smoothly— and more economically.
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HOT TIP for the B.I.F.



Do you want a cert?
Do you want to come away
from Castle Bromwich richer
nor what you went in?
Then take my tip—
straight from the 'orse's mouth—

***put your money on* Desoutter**

GRAND STAND No. C412

Castle Bromwich

DESOUTTER BROS., LIMITED, THE HYDE, HENDON, LONDON, N.W.9. TELEPHONE: COLINDALE 6346 (5 LINES) TELEGRAMS: DESPNUCO, HYDE, LONDON.
CBC265

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ON HEAVY DUTY DRILLING UP TO 4" DIA.



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With ample power and rigidity, these machines are capable of drilling up to 4 in. from solid, in mild steel, on continuous duty. At G. & J. Weir Ltd., Glasgow, for instance, this 32 in. machine is drilling and boring valve boxes from solid, stainless steel. A 3-operation combination tool is used for several bores and limits are maintained within 0·001 in.

These machines are built in three sizes: 28in,, 30in., and 32in., with drilling capacities from solid of 1¼ in., 3 in., and 4 in., dia., respectively.

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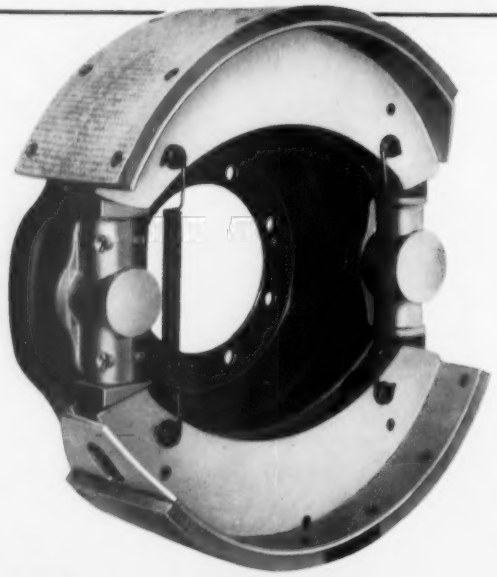
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why GIRLING Hydraulic Brakes are WAY OUT AHEAD

The engineer knows that a solid background of painstaking and rigorous research must support the development and production of all automobile equipment. In no respect is this more vital than in the design and manufacture of brakes. In the progressive Girling organisation unrivalled research and development facilities are purposefully geared to maintain and enhance the proud claim . . .

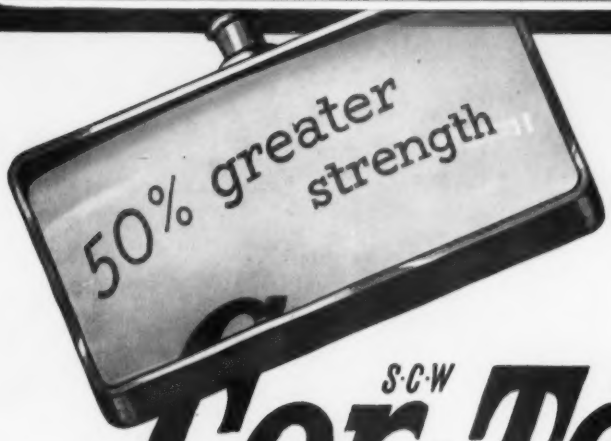


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THE BEST BRAKES IN THE WORLD

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CONSTRUCTION CAN BE LIGHTER WITH COR-TEN



S·C·W BRAND

Cor-Ten STEEL

Cor-Ten is a low-alloy steel of consistent character, combining a high tensile strength with a high resistance to corrosion.

Weight can be saved in two ways. Firstly because thickness, compared with that of mild steel, can be reduced without loss of strength. Secondly, Cor-Ten steel has four to six times the resistance to atmospheric corrosion, quickly forming a self-protecting skin. Allowance for loss of section due to corrosion is thus reduced to a minimum.

Yield point ranges from 20 tons per sq.in. for cold-reduced sheet, to 22 tons per sq.in. for hot-rolled plate and sheet $\frac{3}{8}$" and thinner.

Elongation and cold-bend values are good; working and welding qualities are excellent and so is resistance to abrasion, impact and fatigue.

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Layrub transmission is being adopted more and more by the leading commercial and passenger vehicle manufacturers for fan drives and main drive. The well-known shock absorbing characteristics of Layrub easing the strain on the rest of the transmission. The Layrub system employs rubber trunnion blocks as the main driving elements. There are no metal-to-metal contacts, no lubrication, therefore little or no maintenance. Our latest catalogue will be gladly sent to you on request.

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SHEFFIELD 8

Layrub
TRANSMISSION AT ITS BEST

THE ASTONISHING ACHIEVEMENTS OF PLASTICS IN INDUSTRY

Plastics in electricity, in textiles, transport, commerce and cars, and a host of new fields

Learn what plastics can do for you in your business by visiting the 3rd British Plastics Exhibition and Convention—at Olympia, London, from June 1-11. There you will see, in colourful and all-embracing array, everything the British plastics industry has to offer—the latest materials, machines and moulding presses—the whole range of finished articles from curtains to car bodies.



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The biggest and most practical exhibition of British plastics ever presented. Plan your visit NOW!

Exhibition staged every second year by the journal "BRITISH PLASTICS"

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The product, cine-camera driving motors. The problem, to check the motor speed. But—to check it quickly, accurately, infallibly; with the minimum of mental strain on an operator who is working at high speed. And — a complication: the speed-measuring instrument must not take any power from the camera motor.

The answer? A beam of light: interrupted by the shutter on the camera. The magic eye counts the interruptions, electronic gear translates them into r.p.m.—as a direct reading on a dial. Eureka? But electronic speed measuring is **only one of the many aids to Productivity that electricity can bring you**

Having a hand in Productivity

In every industry or trade, electrical equipment is the key to modern production methods. There are probably more production-boosting and money-saving devices than you know of. Your Electricity Board can help you and give you sound advice.

They can also make available to you, on free loan, several films on the uses of electricity in Industry — produced by the Electrical Development Association.

E.D.A. are publishing a series of books on "Electricity and Productivity". Four titles are available at the moment; they deal with Higher Production, Lighting, Materials Handling, and Resistance Heating. The books are 8/6 each (9/- post free) and the Electricity Boards (or E.D.A. themselves) can supply you.

The British Electrical Development Association
2 Savoy Hill, London, W.C.2

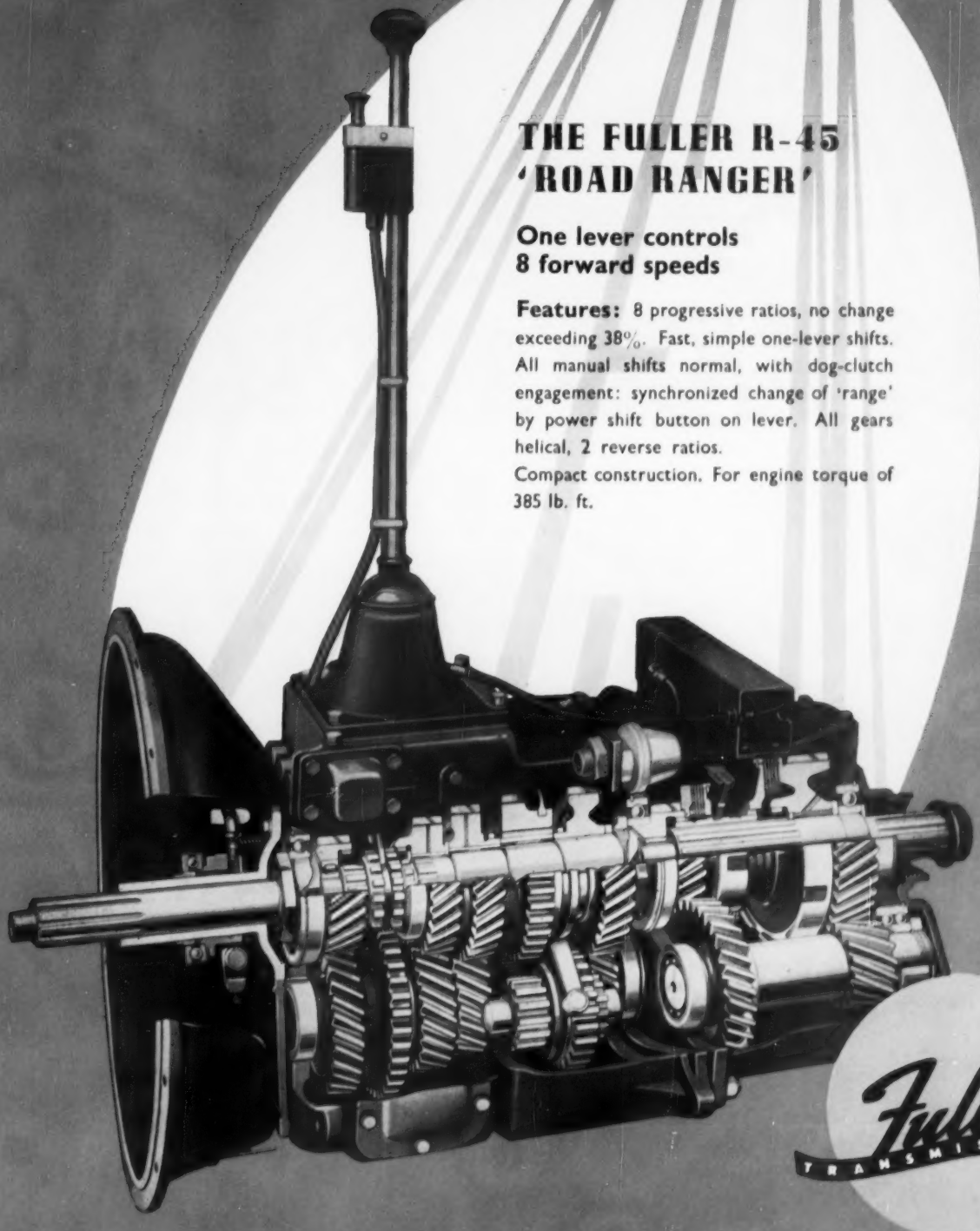
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a Power of Good
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NEW

THE FULLER R-45 'ROAD RANGER'

One lever controls 8 forward speeds

Features: 8 progressive ratios, no change exceeding 38%. Fast, simple one-lever shifts. All manual shifts normal, with dog-clutch engagement: synchronized change of 'range' by power shift button on lever. All gears helical, 2 reverse ratios.
Compact construction. For engine torque of 385 lb. ft.



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Telephone: Langham 2527

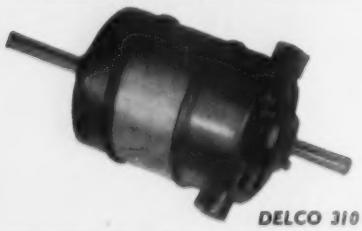
IT'S A GOOD PLAN WHICH INCLUDES



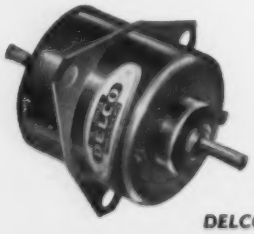
DELCO motors



DELCO 6½" TYPE



DELCO 310 TYPE



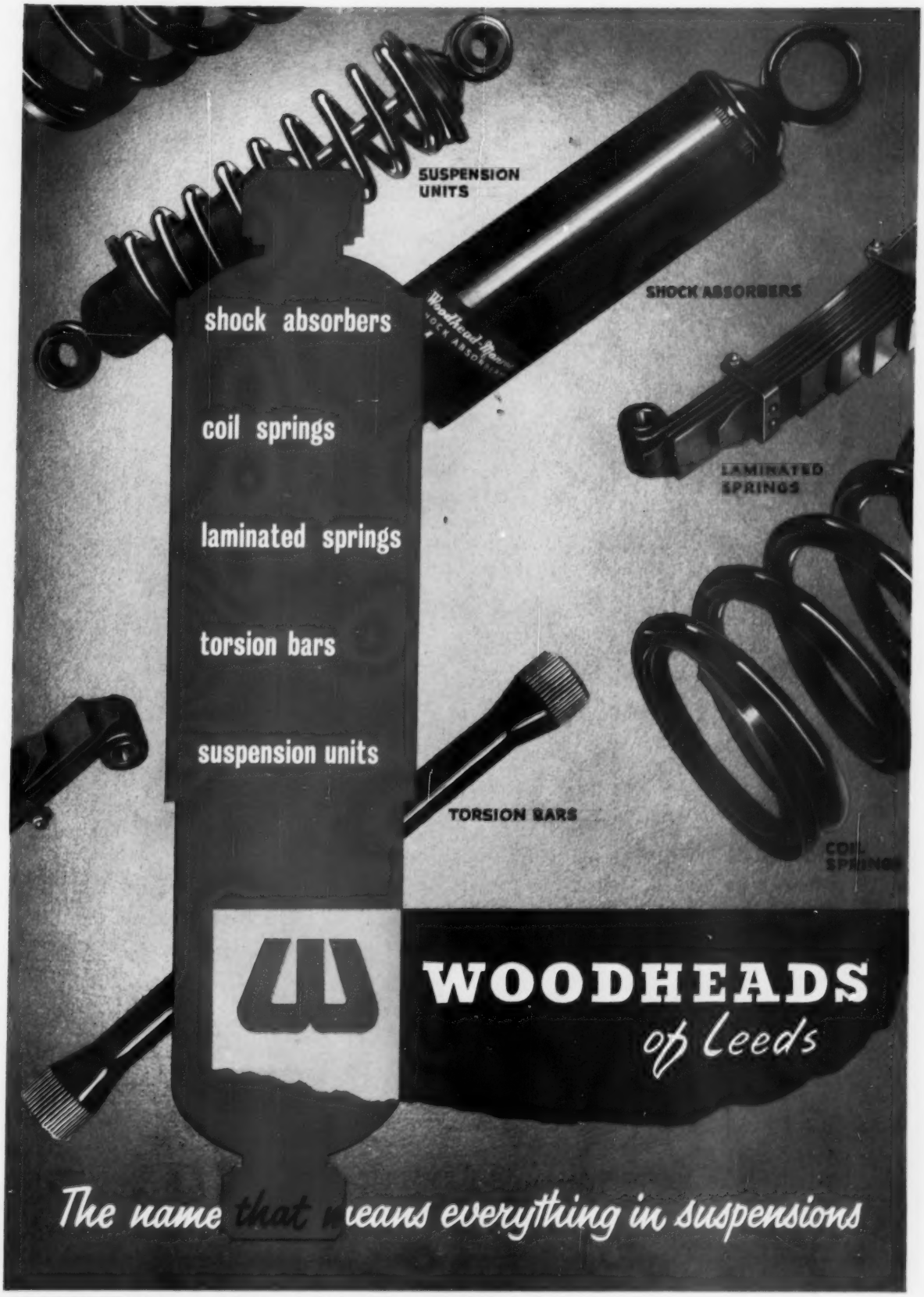
DELCO 258 TYPE
with flange mounting

Before you start work on your plans for Automobile applications which call for compact, high-efficiency electric motors. . consult Delco engineers. The Delco range includes motors to meet most modern requirements—from car heaters to axle gear shifts. These versatile motors are so designed as to be easily adapted to suit your individual needs.

Write for descriptive leaflet featuring motors for use in—

CAR HEATERS · AIR CONDITIONERS AXLE GEAR SHIFTS · RADIATOR COOLING FANS · WARNING BELLS AND SIRENS · POWER OPERATED BONNETS, LUGGAGE LIDS, WINDOWS, SEATS, ETC.

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The Scientifically Designed Oil Seal for Rotary Shafts. A Gaco Product.



ANGUS OIL SEALS

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FLUID SEALING ENGINEERS

NEWCASTLE UPON TYNE, 6



When **weight** is a problem

Come to think of it, weight nearly always *is* a problem.

In almost every branch of industry — and particularly in transport — weight saved means greater all-round efficiency and economy.

That's where light, strong and durable 'Kynal' wrought aluminium alloys come in—enabling weight to be reduced without loss of strength. With the aid of the Technical Service and Development staff of I.C.I. Metals Division, engineers and designers are constantly finding new uses for 'Kynal' alloys.

May we help solve *your* weighty problems?

'KYNAL' AND 'KYNALCORE' wrought aluminium alloys are already extensively used in the following industries:

Aircraft: *ribs, spars, engine components, stressed skin covering, fittings, etc.*

Railways: *structural members, roofing, panelling, windows, luggage racks, etc.*

Road Transport: *structural members, floor planks and panelling, windows, tread strips, doors, small fittings, etc.*

Shipbuilding: *bridges, wheelhouses, outer funnels, lifeboats and davits, decks, skylights, stanchions, bulkheads, watertight doors, etc.*

Building: *roof coverings, side claddings, ventilators and windows, panelling, interior fittings, etc.*

'KYNAL' AND 'KYNALCORE' WROUGHT ALUMINIUM ALLOYS

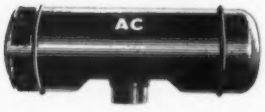
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IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON, S.W.1

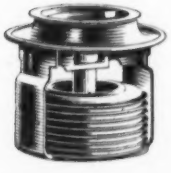
M.323



AC OIL FILTERS



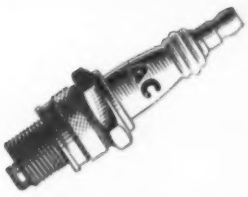
AC AIR CLEANERS AND SILENCERS



AC THERMOSTATS

Plan your future models with

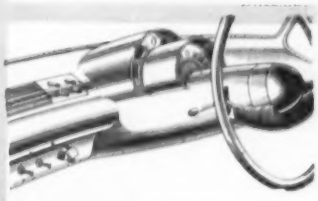
AC QUALITY PRODUCTS



AC SPARK PLUGS

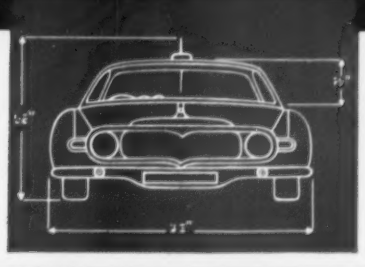


AC FUEL PUMPS



AC INSTRUMENTS





VIRTUALLY EVERY BRITISH CAR has one or more AC Components designed into it on the drawing-board. We'll gladly help you plan a new design or modify an existing one.

Write to :

AC-DELCO DIVISION OF GENERAL MOTORS LTD., DUNSTABLE, BEDS.

Telephone: Dunstable 1166. And Broadgate House, Coventry. Telephone: Coventry 40491



and in Helicopter development

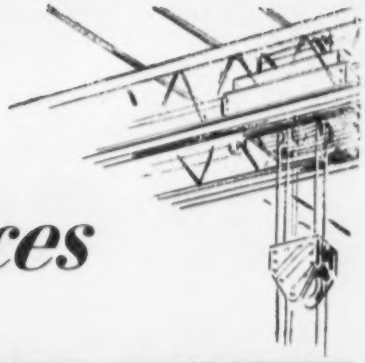
The Fairey GYRODYNE has specially designed

Hoffmann Bearings are well to the fore. The Gyrodyne with its jet-driven rotor blades is a case in point. Hoffmann Bearings have been specially developed by our Technical department in collaboration with The Fairey Aviation Co. Ltd., and are used on the Fairey gear box driving the superchargers, the gear train driving the propellers on the wing and a large special bearing for the rotor blade mounting. In addition, they are also used on the Alvis Leonides engine.

HOFFMANN BALL AND ROLLER BEARINGS

THE HOFFMANN MANUFACTURING CO. LTD., CHELMSFORD, ESSEX

Redifon
R.F. Heating Services



A NOTABLE CONTRIBUTION TO MOTOR PRODUCTION



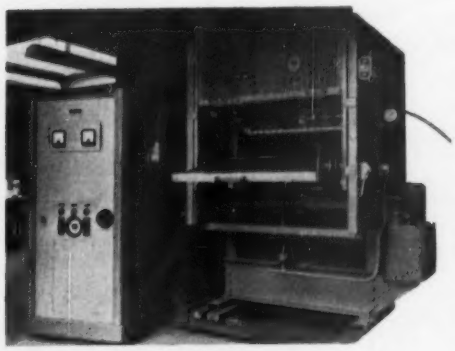
✳ *in the heat treatment of metals*

Redifon are today providing the most complete R.F. heating services to industry. As used by the leading automobile manufacturers, the application of these services is a wide one, and embraces the hardening of valve rockers and tappet screws, rocker shafts, starter ring gears and valve rockers after local carburising . . . local annealing of door panel pressings and tappet covers . . . annealing camshaft gears after carburising and hardening . . . silver brazing petrol filler assemblies . . . soft soldering petrol tank fittings and fixing clips to bonnet flutes. Melting battery connectors, glueing, shrinking, upsetting, and drying are applications of this comprehensive service.

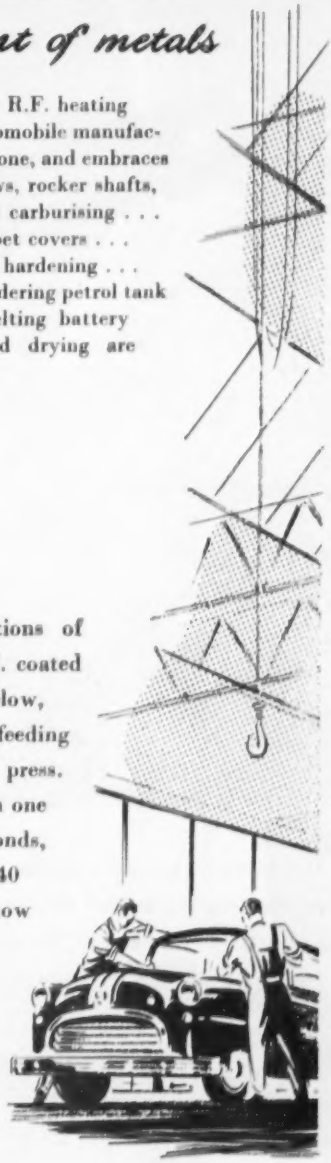
IH.39 9kW. generator fitted with work bench for simultaneous annealing of two camshaft gears supplied to the Austin Motor Co.

✳ *in the welding of P.V.C. materials*

One of the most important and technically interesting applications of Redifon R.F. Heating is the welding of upholstery made from P.V.C. coated fabrics. A typical installation for welding a car door trim is shown below, with a Redifon 6kW. RH16 feeding coaxially a 15 ton hydraulic press. Complete door trims are welded in one operation in approximately 20 seconds, giving a floor to floor time of 30 - 40 seconds. Similar techniques are now being developed for welding seat backs, using more powerful machines. Write to Redifon for full details of these and other welding and trimming applications.



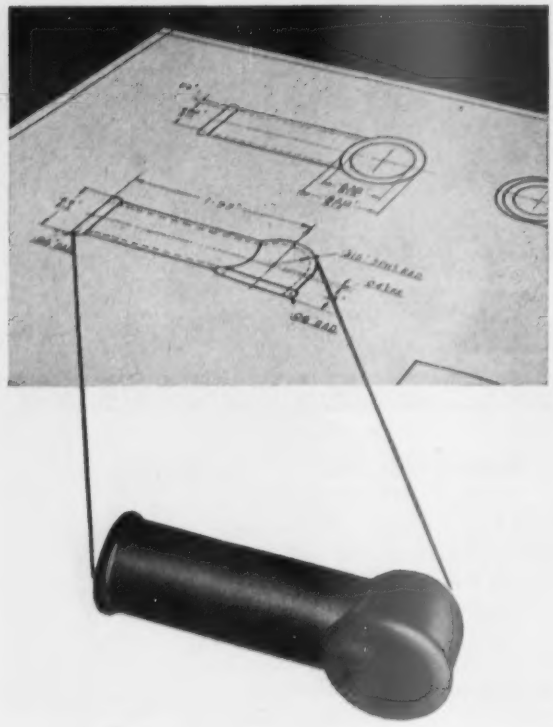
RH16 at Vauxhall Motors



Industrial Electronics Division

REDIFON LIMITED, BROOMHILL ROAD, LONDON, S.W.18. Phone: VANdyke 7281

A Manufacturing Company in the Rediffusion Group

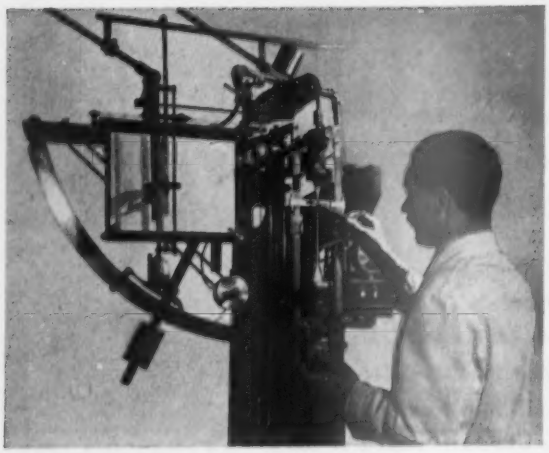


PROTOTYPE MOULDINGS *in* RUBBER

A Special Service to Industry

Experimental and development work is greatly facilitated by St. Helens' Prototype Moulding Service. Small quantities of rubber mouldings can be produced with a minimum of delay and without costly tooling, exactly to the specification of the designer.

An experienced staff is available to co-operate on technical problems, including the development of special compounds to meet specific conditions.



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St. Helens

INDUSTRIAL MOULDINGS

In Natural and Synthetic Rubbers

As pioneers in Rubber Technology, St. Helens have wide experience in the progressive application of rubber in the service of industry. If you have new components in mind, or are considering the possibilities of rubber as an alternative material, your enquiries will be welcomed.

ST. HELENS CABLE & RUBBER CO., LTD.,
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Brake Drums

PAR EXCELLENCE



Cast in

CHROMIDIUM

for Perfect Security

MIDCYL

THE MIDLAND MOTOR CYLINDER CO. LTD., SMETHWICK, STAFFS.

ONE VEHICLE OF Blue Cars CONTINENTAL COACH CRUISES LTD COVERED

24,000 Mountain miles without renewing brakes!



THE BEST CONTINENTAL HOLIDAYS BY MOTOR COACH

Blue Cars
CONTINENTAL COACH CRUISES LTD.
224 SHAFTESBURY AVENUE
LONDON, W.C.2, ENGLAND

Messrs. Clayton Dewandre Co. Ltd., 10th November, 1954.
Titanic Works,
LINCOLN.

Dear Sirs,

You will remember that before our 1954 season started you equipped four of our 30ft x 8ft 9 ton Coaches with the Oetiker exhaust brake.

Our season is now over, and we thought you might be interested to have a few details as to how they have performed.

Coach No. M.F.342 covered 24000 miles during the season on our Italian Tour. No brake drums were replaced and on examination of the brake linings we find that 9/16" of the original linings still remain. A similar coach which operated on the same route had two changes of brake linings and one change of brake drums. The itineraries on which these coaches operated took them through seven countries and over the St.Gotthard, Susten, Brunnig and other Passes. Those coaches fitted with the exhaust brake were able to descend the hills more quickly and, of course, much more safely owing to elimination of brake fade.

The financial saving has been considerable and we are now looking forward to the remainder of our fleet being similarly equipped.

Yours faithfully,
for BLUE CARS CONTINENTAL COACH CR
R.J.K. Hurrassen.
TRAFFIC MANAGER

Blue Cars

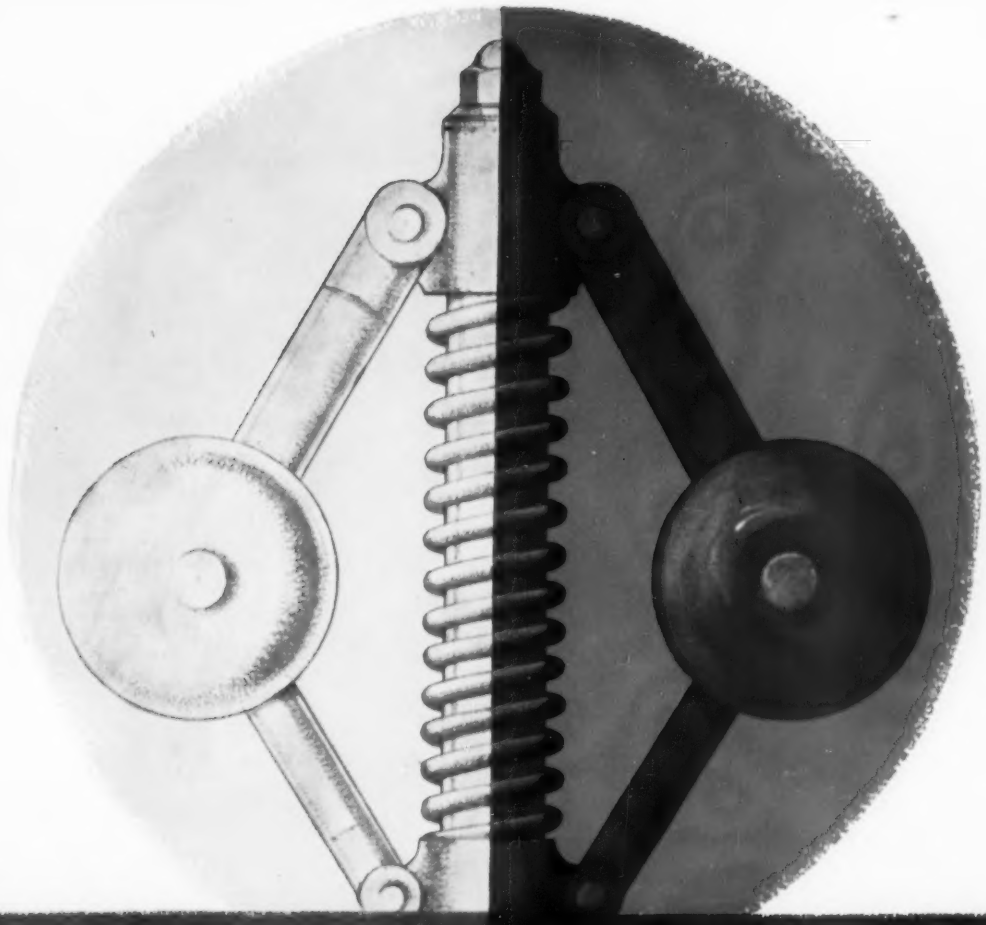
successful experience with Clayton Oetiker exhaust brakes is shared by other cost-conscious fleet owners

★ You owe it to yourself to investigate this superior braking system. Just 'phone or write us for specific information. Or ask to have a Clayton representative call on you.



CLAYTON DEWANDRE CO. LTD.

LINCOLN · ENGLAND Phone: 11305-9



ACCURATE **ROBUST**

Evolved after many years of specialization, the Iso-Speedic governor controls speed to an extraordinary degree of accuracy, due to the elimination of static friction by rolling flybobs.

Iso-Speedic governors can be supplied which control speed within 0.3 per cent: others are available where a lower degree of accuracy is sufficient.

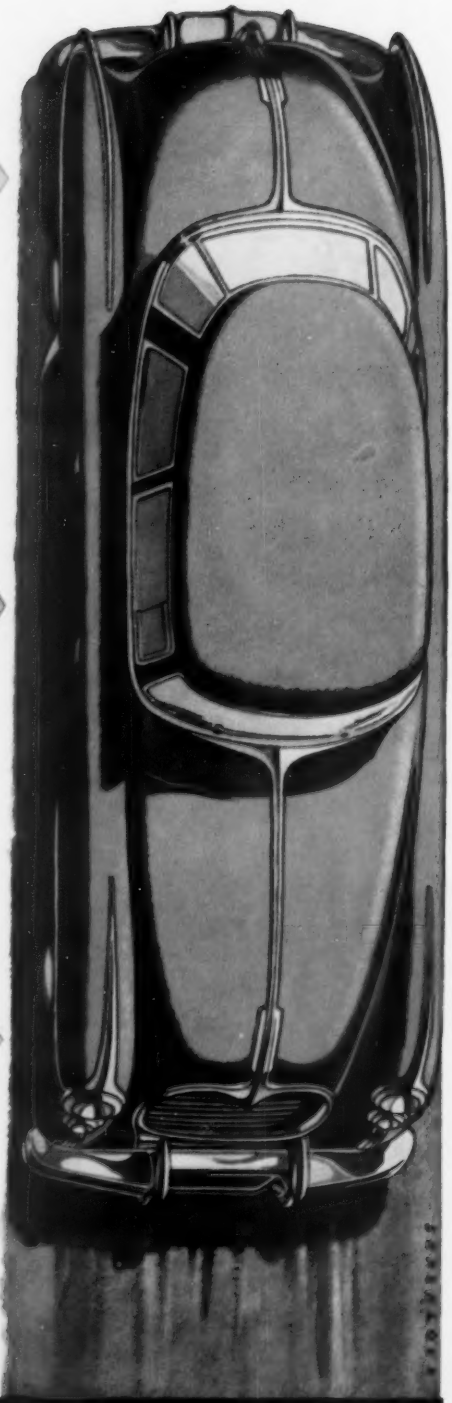
Servo action, exercising any desired force, can be arranged, and the services of our engineers are at your disposal.

THE ISO-SPEEDIC COMPANY LTD., FRIAR'S ROAD, COVENTRY
Telephone: Coventry 3147 Telegrams: Isospeedic Coventry

Iso-Speedic

There is no material more suitable for bright-work on motor vehicles than stainless steel. Solid metal throughout, nothing to chip, peel, or rust. Stainless steel trim is thoroughly practical. It requires *no polishing* and is quickly and easily cleaned merely with soap and water.

Body stylists are making increasing use of this gleaming material—decorative mouldings, window reveals, radiator grilles, lamp housings, wheel discs. Irresistible in the showroom, endurable for the whole life of the car. Small wonder that the Motor Industry all over the world is turning to stainless steel —the metal of the age.



"SILVER FOX"
STAINLESS STEEL

REGD. TRADE MARKS

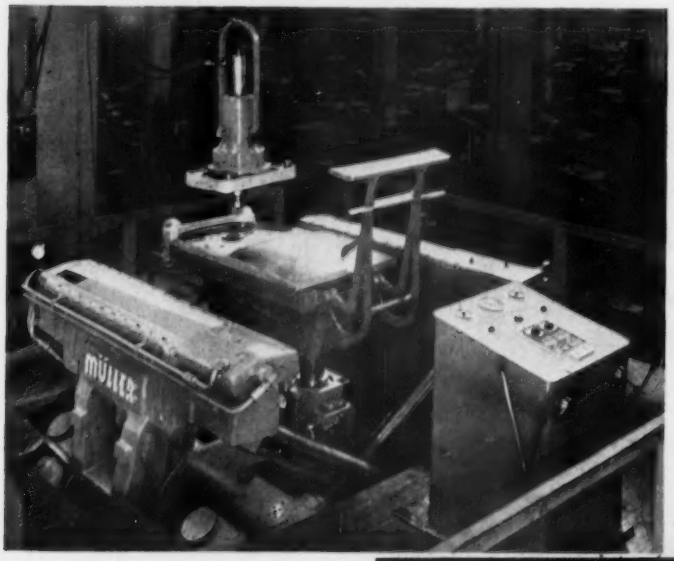
The metal of the age

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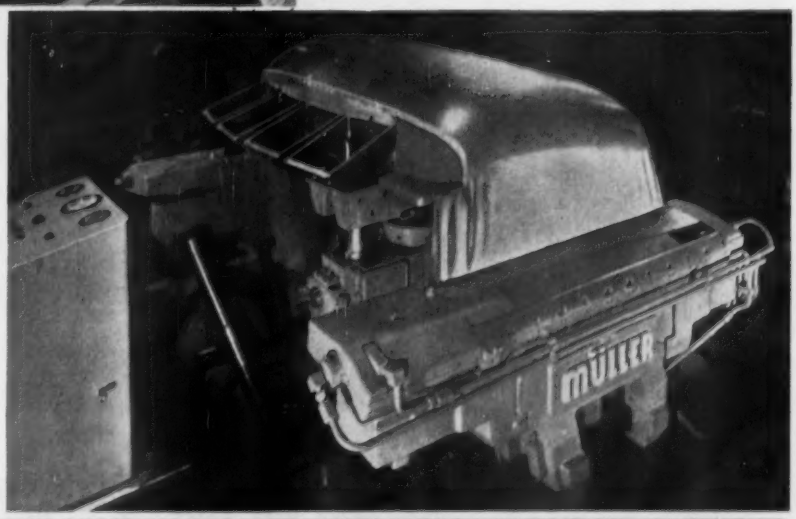
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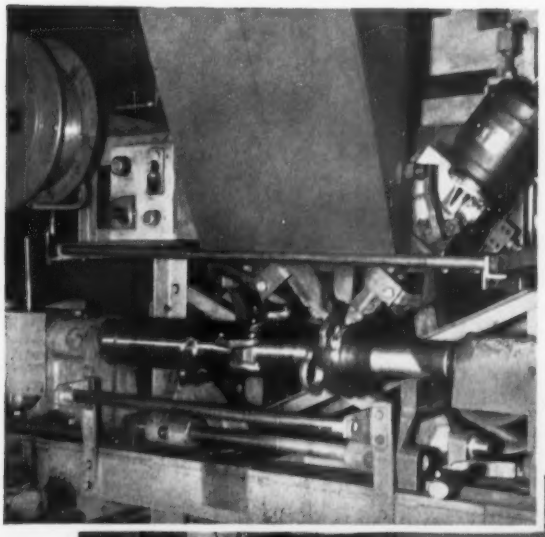
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Lincoln automatics speed up truck production



The latest Lincoln automatic welding set-up is increasing production for Vauxhall Motors Limited at Luton. It gives them better joints and greater penetration than is possible by hand-welding.

Nine different types of rear axle-tube assembly—for the Bedford and Big Bedford range—are being Lincolnwelded by the Bedford rear axle division, working two shifts a day, five days a week. Fifty-three per cent of all this division's welding is now done by the automatic submerged arc-welding process, considerably saving manpower and increasing output.

Output is running at 156 assemblies per shift and the automatic welding equipment performs circumferential fillet welds on the axle tubes simultaneously.

The standard Lincolnweld equipment, consisting of two inclined, fully automatic heads, generators and control panels, has been specially adapted by Vauxhall engineers. Welding time, approximately 63 *seconds*, compares spectacularly with manual welding time of 11 *minutes*.

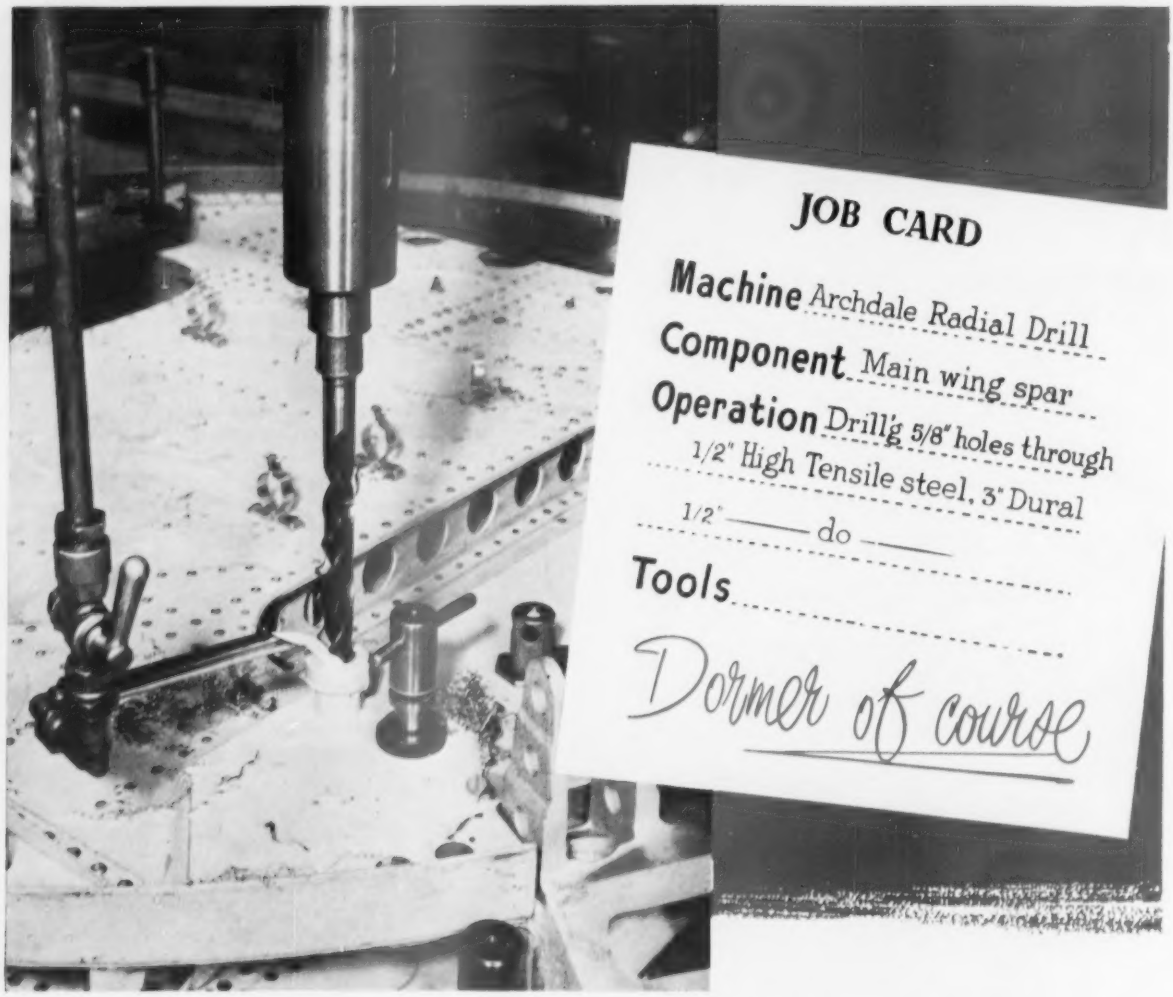
The Lincolnweld process is explained in a brochure available from Dept. U.



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The range includes a fixing PANEL UNIT—a PANEL MOUNTING COUPLER and a CABLE COUPLER—each designed to mate with the common CABLE UNIT (as illustrated).

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All types are available with the following contact combinations:

22-way—10 amp; 4-way—50 amp; 3-way and 1 Earth return—50 amp.

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These connectors comply with the M.O.S. specification for climatic proof components.

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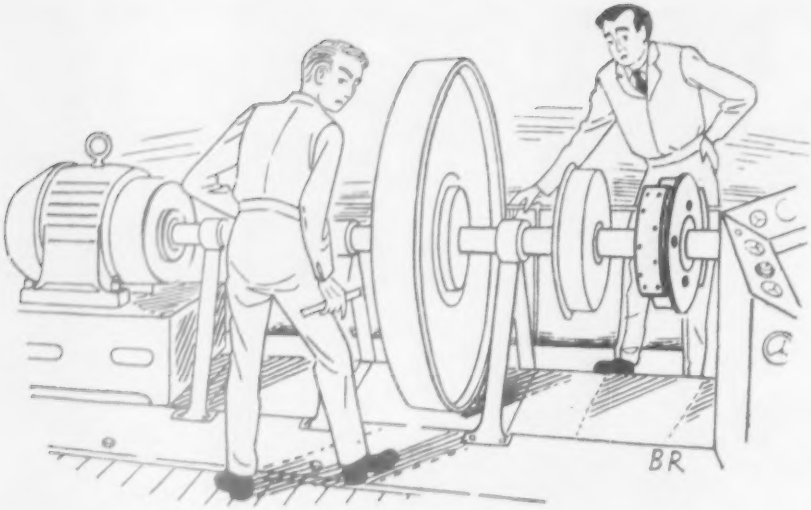


Publication No. 731 giving full information on the complete range of Plessey Heavy Duty Connectors is available to manufacturing and Government Department executives and to design engineers, free on request.

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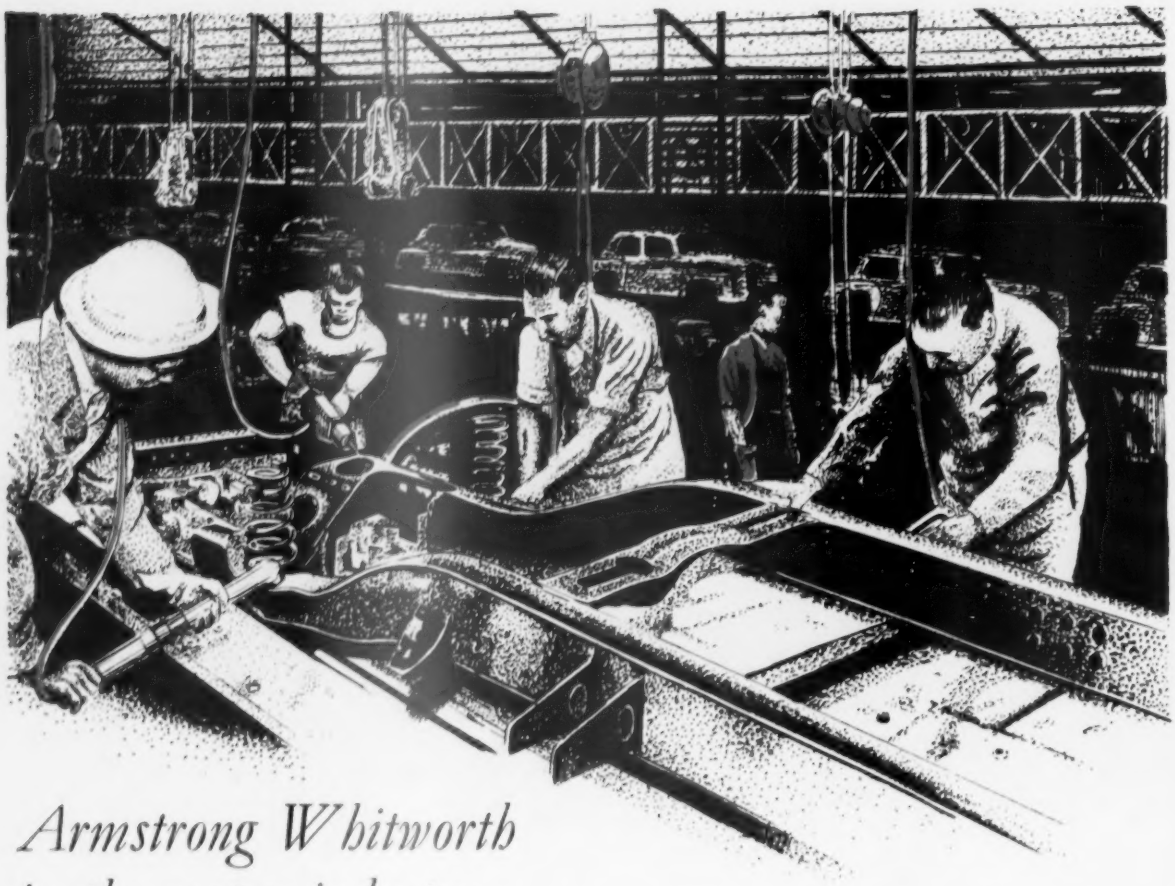
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P.67 R.15

What's under the famous HARPER SKIN





The familiar photograph of the "casting that is smoother than the human skin", takes on a new aspect when a gamma-ray photograph of the typewriter segment casting is superimposed upon an X-ray photograph of the hand.

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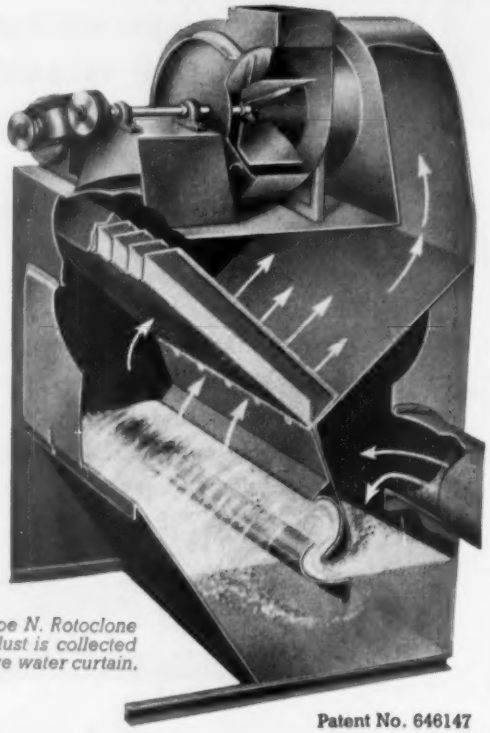
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Cutaway of Type N. Rotoclone showing how dust is collected by the distinctive water curtain.

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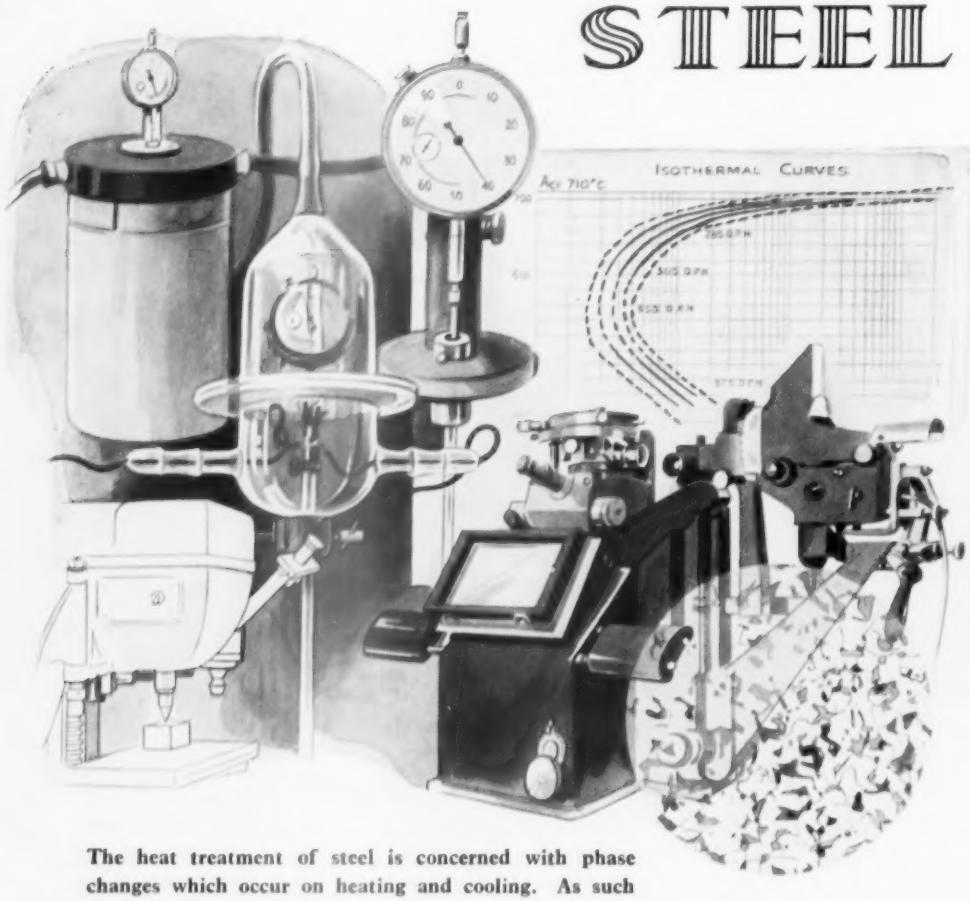
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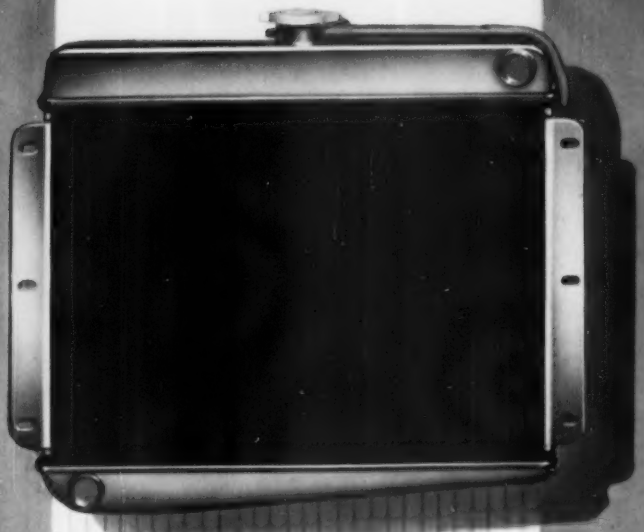
This is the ninth in a series of illustrations of highly specialised equipment devised to control the production and testing of special steels by William Jessop & Sons Ltd.

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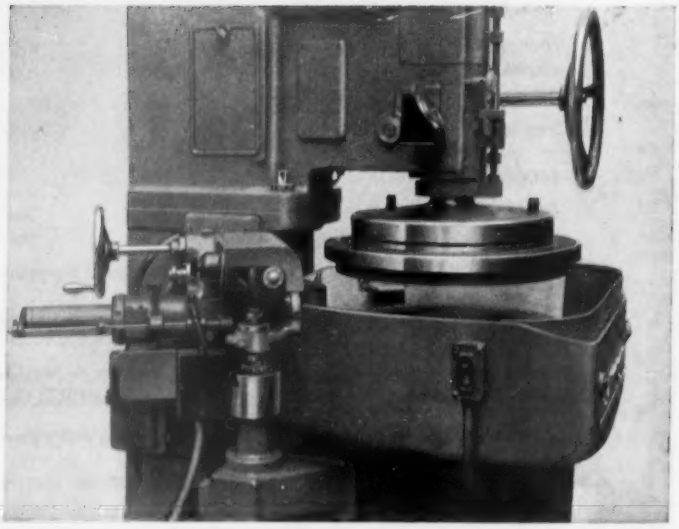
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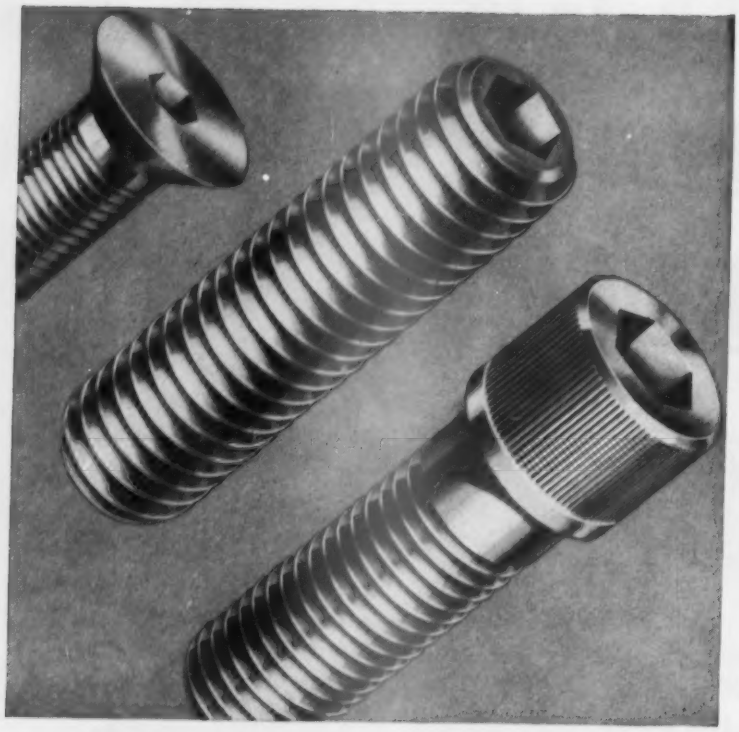
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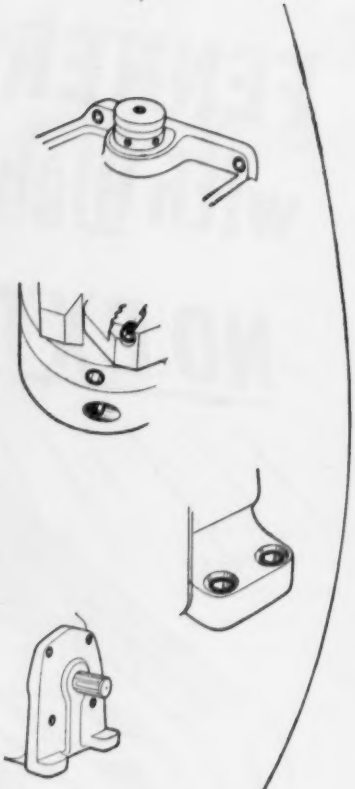
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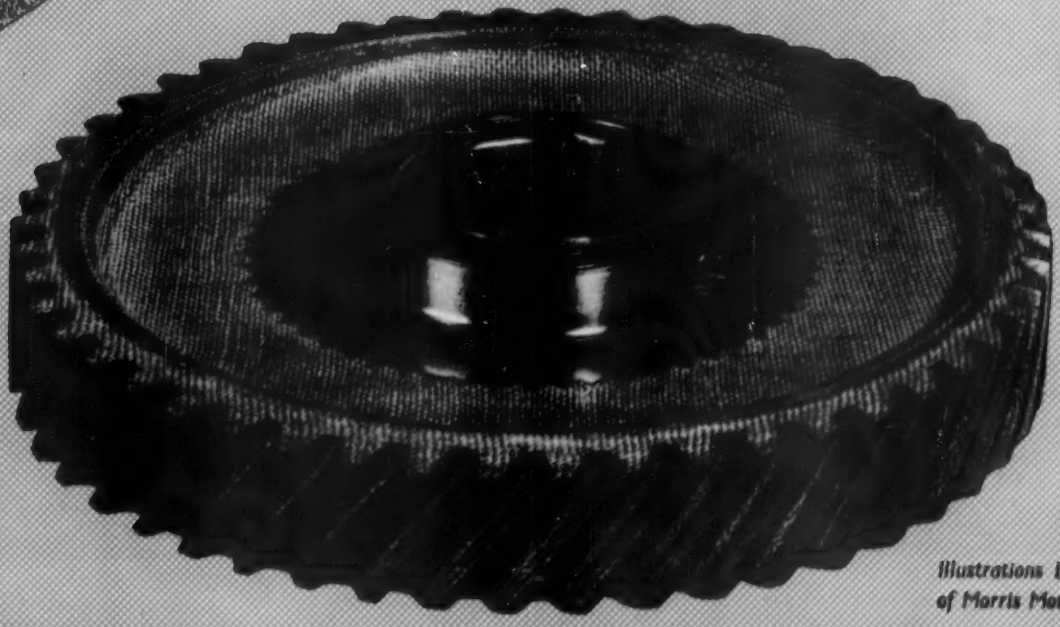
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The illustrations show a sectioned gear blank and the finished spur gear



Illustrations by courtesy of Morris Motors Limited

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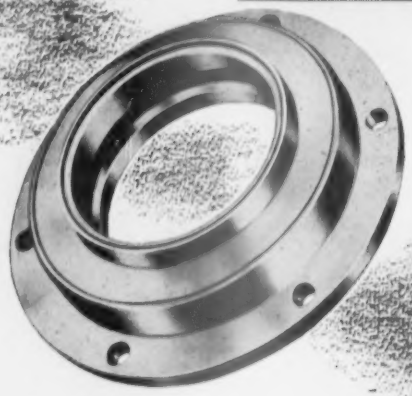
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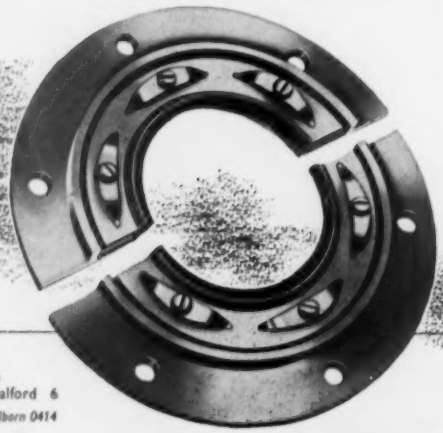


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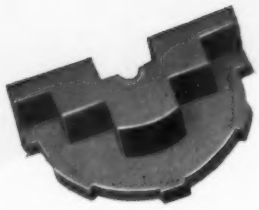
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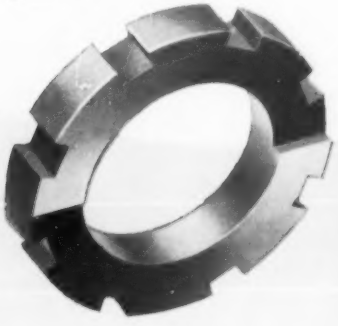


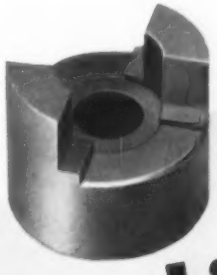
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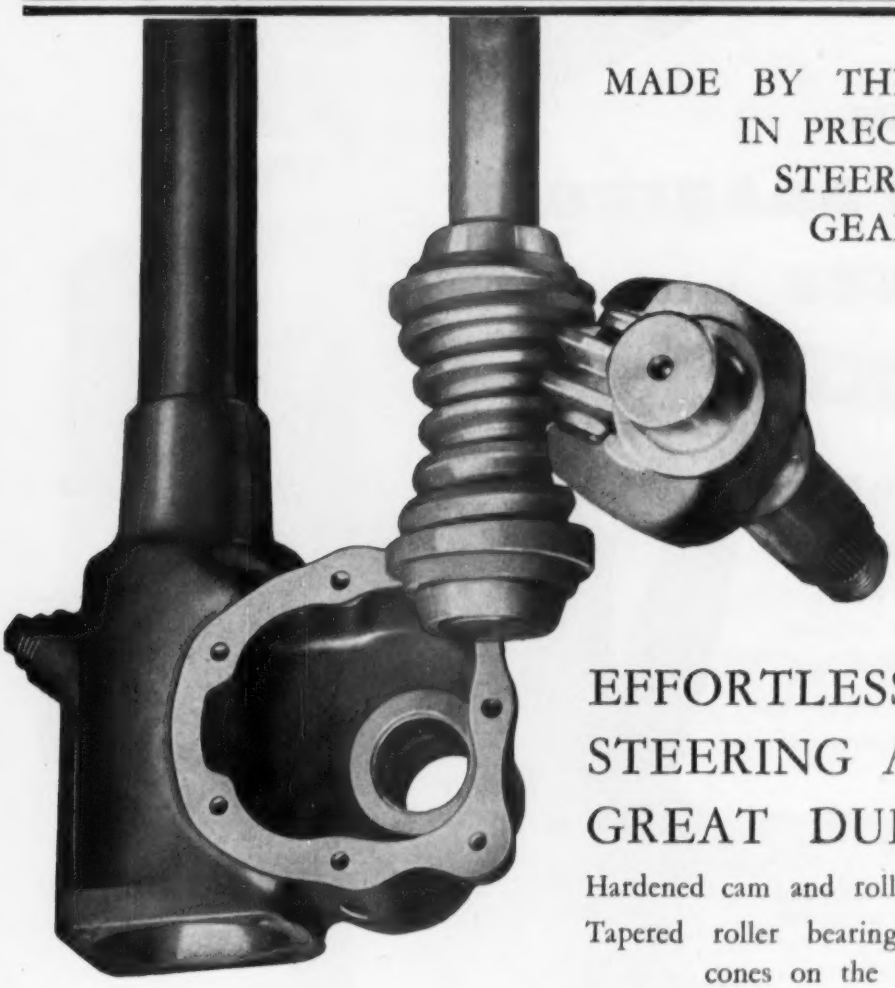
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Illustration left: A standard 5kW unit, for brazing carbide tool tips; photograph by courtesy of EDIBRAC LTD., Broadheath, Cheshire, manufacturers of Tungsten Carbide products.

Designs are completed for standard 6", 8" and 12" furnaces; may we send details? We should also be pleased to arrange a visit to our Heat Treatment Division, near the main works in Tyburn Road, where test pieces can be brazed in a furnace of this type.

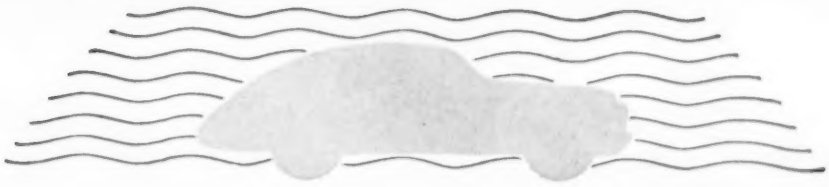
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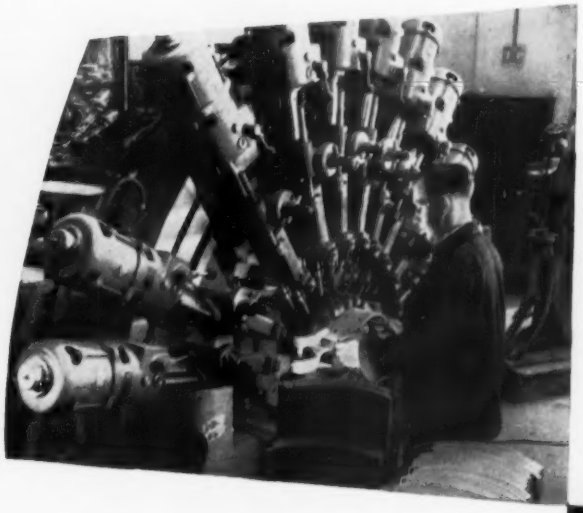
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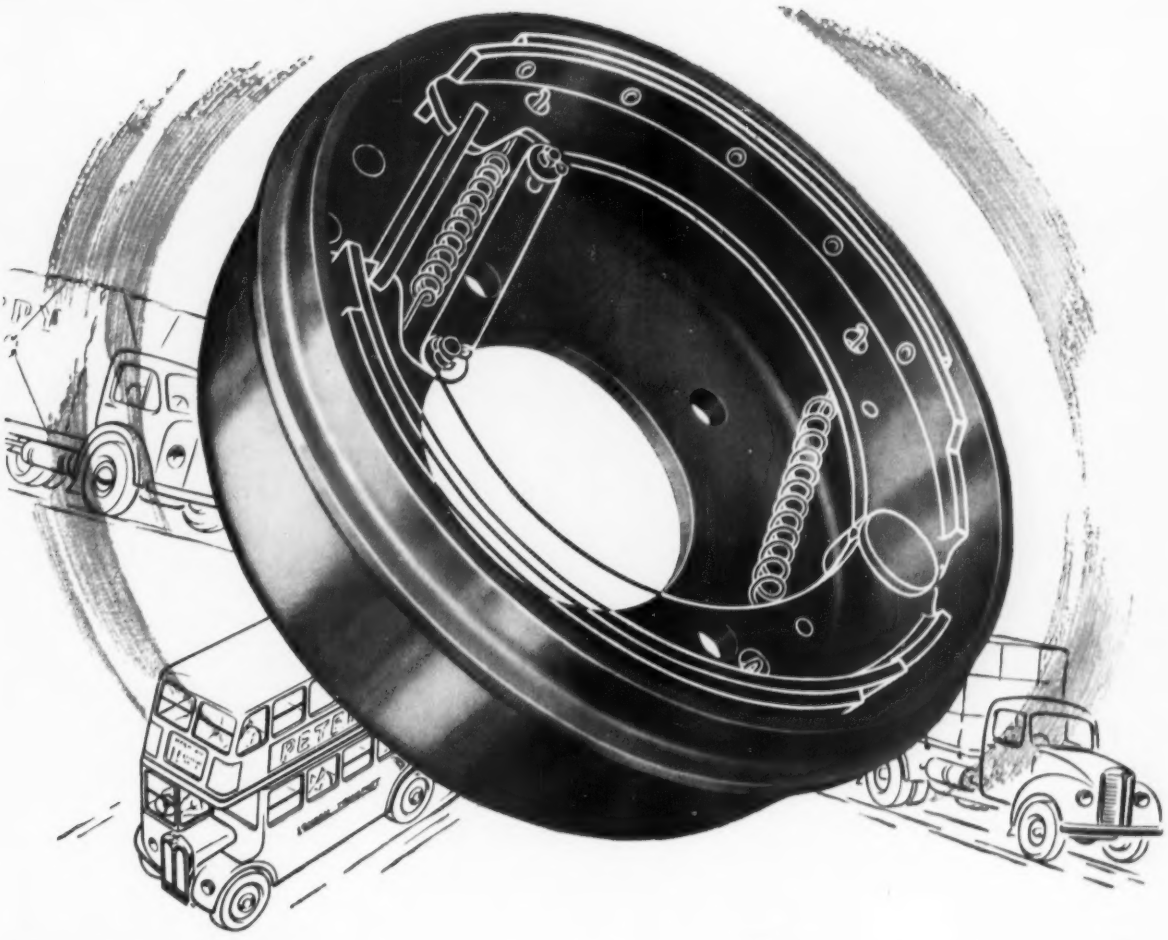
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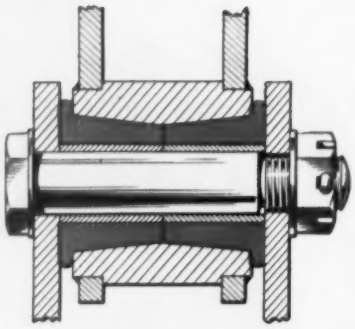
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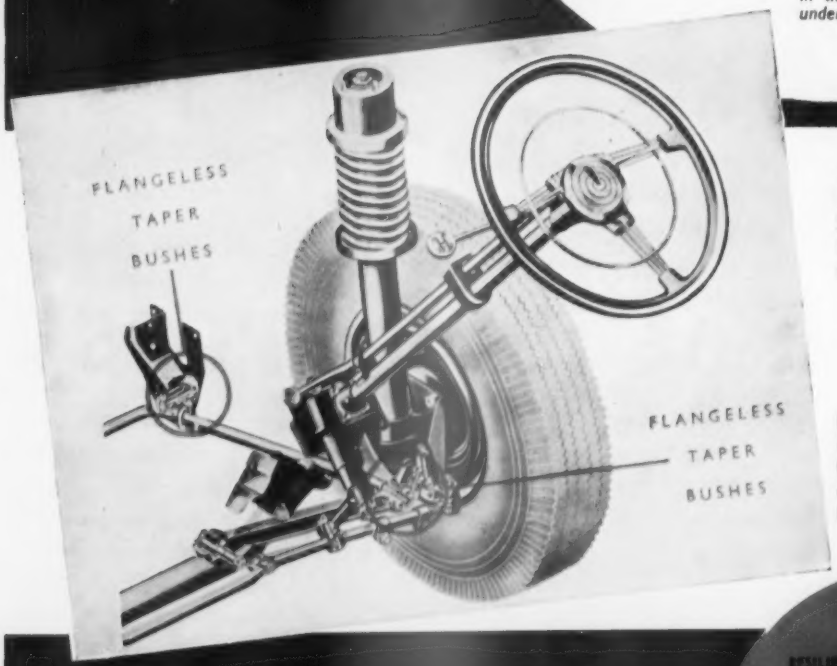


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Constructed on the Silentbloc principle with a self-forming flange for extra-snug fitting and less wear these bushes ensure maximum efficiency at lowest cost.



Right: Flangeless Taper Bush sectioned to show construction. In the housing flanges develop under compression.



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Left: Front Suspension of the "Consul" and "Zephyr Six".

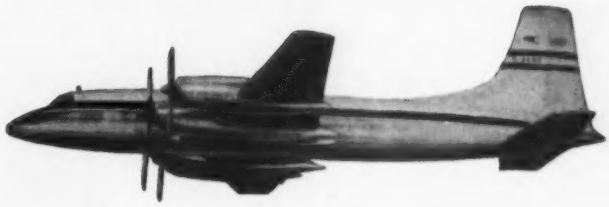
Flangeless Taper Bushes and Frustacon mountings provide the first complete and scientifically designed rubber insulation between wheel and body.

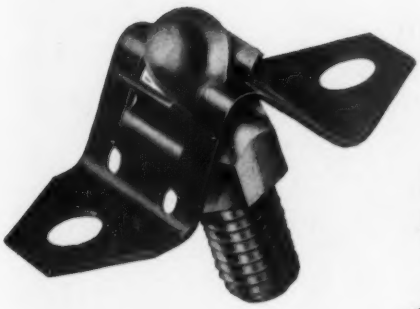
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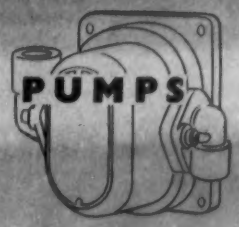
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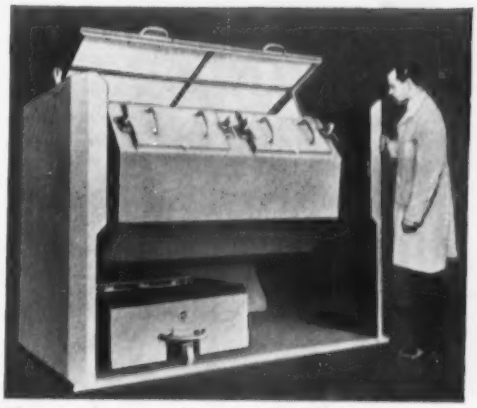


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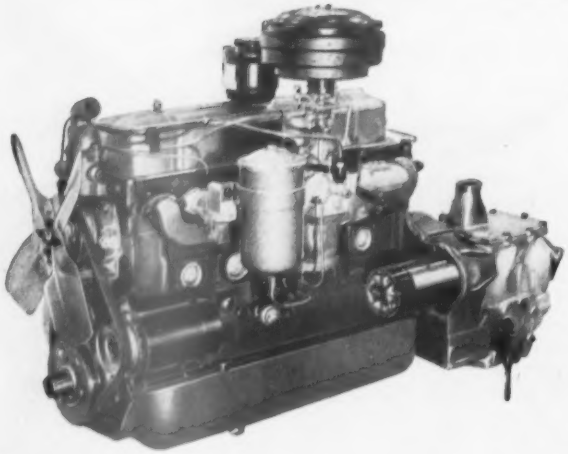
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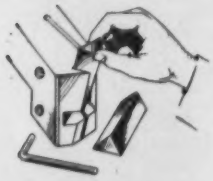
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These tools may be used in any combination one with another or incorporated with standard tools in a set-up.



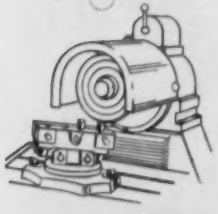
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Tool performance is improved since the solid carbide inserts are secured entirely by mechanical means and thus remain free from the stresses usually inherent in brazed tools.



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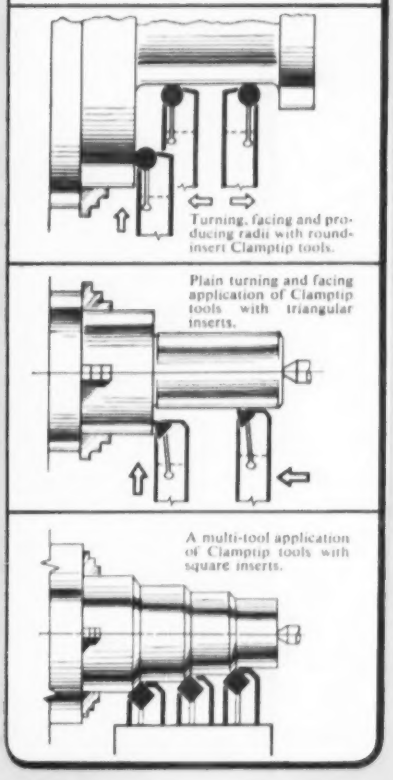
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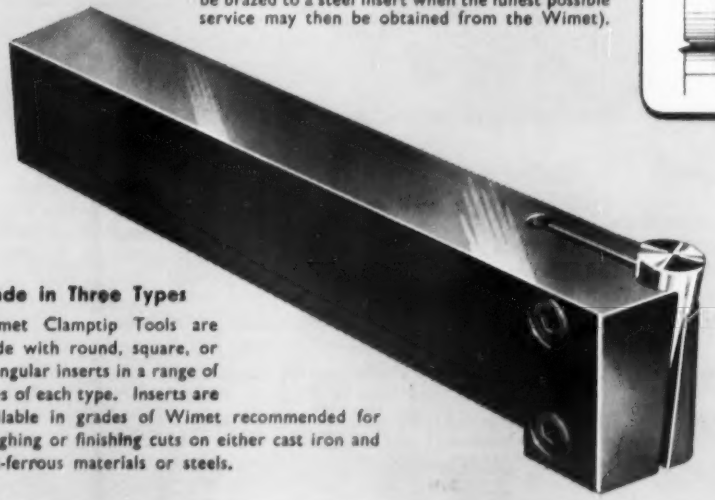
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The Automatic Factory

THERE is much truth in the American dictum that "the cheapest handling is always the handling you don't have to do." This, of course, is not a universal truth, since the availability and price of labour are important factors in determining the economics of mechanical, as opposed to manual, handling of work. It is, however, substantially true of all highly industrialized countries, and particularly of the United States of America.

During the past decade the American automobile industry has made considerable progress towards the automatic factory and the developments for the production of 1955 models show that progress is continuing at a greatly accelerated rate. Probably the most important developments have been those in devices for transferring work from one machine, or banks of machines, to another and for changing the position in which the workpiece passes through the machines. These devices are, of course, pre-requisites for any further advance towards the fully automatic factory. Their development in this country has lagged far behind American practice; in great measure this is due to differences in output.

Cylinder block machining

It is not difficult to envisage a fully automatic machining line for cylinder blocks, in which the block is loaded at the first station and then passes through the complete operational sequence and is delivered to the assembly section without being touched by hand. Such a line would have to include automatic inspection devices for every dimension, and the devices would have to embody some means of identifying and, if possible, ejecting faulty parts from the machine production line. For instance, an interesting inspection station has been incorporated in an American cylinder block line. On its journey through the machine, the block is pressure tested for leaks. If a leak exists, the faulty workpiece is automatically marked with yellow paint in a predetermined location. The block then continues through the machine for the completion of all subsequent operations, and there is no hold up of production. At the end of the line, the blocks pass an electronic eye, and any block bearing the yellow paint mark is picked out by the electronic eye and automatically shunted to a conveyor leading to the salvage section.

Whether it is a cause of the rapid American advance towards the fully automatic factory or a result of the advance is not certain, but in recent years several concerns have been organized solely for the development and manufacture of automatic devices for use in conjunction with multi-station transfer machines. They have indeed played a most important part. The design and manufacture of the units controlling the cutting tools remain with established machine-tool manufacturers, while the newer organizations concentrate on developing automatic handling and inspection devices.

The automobile industry in this country already makes wide use of relatively small engineering firms for many precision jigs and fixtures. Because of this there is close liaison between the automobile industry, the machine tool makers and the manufacturers of jigs and fixtures. It would be to the advantage of all concerned if the makers of jigs and fixtures were able to undertake the development of automatic devices for loading work into machines, for transferring work from one machine to another and for inspecting work.

The development of suitable devices should not present any serious technical difficulty since the principles involved have already been widely employed in the British automobile industry. For instance, it is now commonplace to employ mechanical motions that are synchronized with other motions and initiated by some form of limit switches. What may be more difficult is to devise units that can readily be modified to conform with design changes. There is always a danger that the increased complexity and first cost of modern production equipment may act as a brake on design progress. It is, therefore, of the greatest importance that the machines and all auxiliary equipment shall be capable of modification.

Social aspects

In addition to the technical aspects of the subject, there is also the important social aspect. In the United States of America, where hitherto the workers on the shop floor have given a ready welcome to the introduction of new machines and methods, the Trades Unions are already expressing grave misgivings and are considering opposing any extension in the use of multi-station transfer machines. In this country also, despite the limited use that is being made of transfer machines, the shop stewards in the Midlands have recently expressed disquiet about this development. There are not, at the moment, any real grounds for disquiet, since the men displaced by the introduction of multi-station transfer machines have easily found alternative employment, usually in the same organization. But opposition based on faulty premises can be

dangerous and it should be stilled as quickly as possible by keeping the workers fully apprised of developments and by full explanations of the results that are to be expected.

Whither Design?

FINDING faults with current car design and suggesting future developments are subjects that interest most motorists; they are also particularly engaging fields of speculation for engineers. Many of the unfavourable criticisms and most of the suggestions can be discounted because those who make them obviously do not understand that, though something may be desirable, it is not necessarily feasible. This, however, does not apply to the opinions expressed by Raymond Loewy in a talk at a meeting of the American Society of Automotive Engineers in Detroit.

Some of Mr. Loewy's unfavourable criticisms can scarcely be applied to current British designs; others are applicable, but with far less force than to American. There are two points where American designs are considered to have gone grievously astray. First, the manufacturers have deliberately chosen to produce bulkier and bulkier models. This, of course, has meant increased weight and has been an important factor in the horse-power race which has been one of the dominating features in American automobile development since 1953.

It must be said that engine designers in general never looked upon this race with any great favour, and chassis engineers almost without exception would like to see it quietly forgotten. There is now a campaign to use maximum torque in place of maximum horse-power as a major selling point. However, before this can be effected it will be necessary to re-educate sales staffs and the American public, since both are now thoroughly indoctrinated with the theory that there is some magical virtue in very high maximum horse-power.

Excessive decoration

A second unfavourable criticism was directed against the excessive use of chrome ornamentation. Loewy refuses to believe that this, any more than tremendous engine power, is what the American public really want. Fortunately, British designers have not gone to such lengths in the use of chromium plate as the Americans—we sincerely hope they never will. Nevertheless, some of our designers would do well to remember that while excessive or faulty decoration can spoil the effect of good lines, bad or mediocre lines can never be corrected by added decoration.

Loewy's opinions about the changes that should be made must have caused raised eyebrows even in Detroit. In this country some of them will be regarded as startling, particularly when it is remembered that they are advanced as proposals for immediate development. The changes will be determined by the following factors:—

(1) Better highways and more and faster traffic call for streamlining, smooth undercarriage and improved performance.

(2) With greater traffic density, easier manœuvrability in all directions is necessary.

(3) Semi-automatic driving is more relaxing and therefore more dangerous—devices to protect the occupants of the vehicle should be standard equipment.

(4) People will be owning two or more cars, which will create a greater demand for specialized vehicles.

(5) Much greater emphasis will be placed on safety in car design generally.

Suggested developments

Some of the ways in which these requirements may be met are obvious. For instance, more compact power units will permit lower bonnet lines, with consequent better forward visibility from the driving seat, and Loewy considers that 360 deg visibility is assured and there may be a return to flat windshields to reduce reflections at night. A most surprising suggestion in connection with visibility is that a low-price radar unit will be developed for driving in fog.

Another surprising suggestion is that, in addition to the normal forward and reverse movements, cars should also be capable of lateral movement to allow close parking. While no-one will deny the advantages of close and easy parking, we doubt whether they are worth the extra mechanical complications that would be necessary to give lateral movement. However, such is the ingenuity of American engineers that a statement of the desirability of lateral movement may be regarded as a challenge to produce the necessary mechanism, whether costly or otherwise. It is also suggested that drivers may wear wrist shock coils; alternatively, other means of transmitting body impulses will be found. These will detect the metabolic and neuro-electrical variations that take place in the human body when it relaxes and goes to sleep. They will restore the safety factors lost as driving becomes semi-automatic.

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M.G. MAGNETTE

1½ Litre, High Performance Saloon Car

WHEN the M.G. Magnette was first conceived, it was intended to replace the 1½ litre model. The aim was at a low-built, four-seater saloon of brisk performance, good road holding and steering, and with a braking performance to match its other performance characteristics. This vehicle has been designed for those who appreciate the finer points of driving and who are prepared to pay a little extra for good quality.

It is powered by the B.M.C., four-cylinder, 1,489 cm³ engine, which has a bore of 73·02 mm, a stroke of 89 mm, and a compression ratio of 7·15 : 1. The unit develops 60 b.h.p. at 4,600 r.p.m., and has a maximum torque of 78 lb-ft at 3,000 r.p.m. A three-bearing crankshaft is employed. The well-known heart-shaped type of combustion chamber, characteristic of the B.M.C. engines, is incorporated. A single camshaft in the side of the crankcase actuates the push rods and rockers of the overhead valve gear. This engine, complete with carburettors and air cleaner, weighs 404 lb dry; the gear box and clutch together weigh 80·1 lb.

The kerb weight of the vehicle, with five gallons of fuel, is 2,478 lb and the weight distribution is 54 per cent to the front and 46 per cent to the rear. The engine power per ton is 54·2 b.h.p. This should give lively acceleration. The brake lining area per ton is 104·5 in², a figure that is ample, even in mountainous terrain, for this class of car.

A particularly well-designed transmission system is incorporated. A noteworthy feature is the careful attention to the lubrication of the gearbox. This should help to give long, trouble-free life and, what is perhaps equally important, the noise level should remain low for an exceptionally long period. In less well-designed gearboxes, noise generally begins to develop as a result of wear of the bearings, as a result of which the gears mesh incorrectly. Although the gearbox is a standard unit designed for incorporation in other vehicles, and therefore can be fitted with a steering column gear shift control, in the Magnette a floor-mounted type of gear shift lever is employed, since this type is preferred by most drivers of high performance cars.

A conventional rear suspension system is employed, and a simple semi-elliptic spring layout has been found adequate. There is no anti-roll bar on this vehicle since it is low slung and shows no tendency to undue rolling. At the front, a double transverse link and coil spring layout has been adopted. Care has been taken to ensure that the linkage is sufficiently rigid to avoid undesirable steering characteristics, particularly under the influence of brake torque. This has been accomplished by employing additional links to assist both the lower single transverse link and upper wishbone in reacting brake torque and drag loads. Coil springs have been

SPECIFICATION

ENGINE: Four cylinders. Bore and stroke 73·025 mm (2·875 in) × 89·0 mm (3·5 in). Swept volume 1,489 cm³ (90·8 in³). Maximum b.h.p. 60 at 4,600 r.p.m. Maximum b.m.e.p. and torque respectively 125 lbf/in² and 76·1 lb-ft at 3,000 r.p.m. Compression ratio 7·15:1. Three-bearing crankshaft, fully balanced. Overhead valves, push rod operated. Carburettors: twin S.U. downdraught, with 1¼ in diameter choke. Heart-shaped combustion chambers.

TRANSMISSION: Borg and Beck single dry plate clutch, 8 in diameter. Four forward speeds and one reverse. Ratios: top 1:1, third 1·374:1, second 2·214:1, first 3·64:1, and reverse 4·76:1. Hardy Spicer open propeller shaft.

REAR AXLE: Three-quarter floating unit, with hypoid bevel and banjo casing. Final drive ratio 8:39.

FRONT SUSPENSION: Double transverse link, with brake torque struts and coil springs. Girling, 1 in bore, telescopic, finned shock absorbers; length, 9 3/16 in—8 1/16 in compressed and 14 3/16 in—13 1/16 in extended.

REAR SUSPENSION: Semi-elliptic leaf springs with through axle. Girling, 1 in bore, telescopic finned shock absorbers, 12 in compressed and 19 in extended.

STEERING: M.G., rack and pinion type. 2¾ turns of the 17 in diameter steering wheel from lock to lock. Turning circle 37 ft 6 in.

BRAKES: Front, Lockheed hydraulic, two leading shoe. Rear, Lockheed hydraulic, one leading and one trailing shoe, with mechanical parking brake. Drum diameter 10 in. Shoe width 1¾ in. Total friction lining area 134·4 in².

TYRES: 5·50—5·00. Pressure: front 24 lbf/in², rear 26 lbf/in².

DIMENSIONS: Wheelbase 8 ft 6 in. Track: front and rear 4 ft 3 in. Ground clearance 5⅛ in. Overall length 14 ft 1 in. Overall width 5 ft 3 in. Overall height 4 ft 10 in. Frontal area 20 ft². Curb weight 2,478 lb, with 5 gallons of fuel. Front/rear weight distribution 54·3/45·7. Engine dry weight 404 lb, power unit complete. Body weight 760 lb, without seats and trim. Gearbox and clutch weight 80·1 lb.



The traditional type of radiator grille has been blended tastefully with the modern styling of the M.G. Magnette, which is only 4ft 10in high

employed because torsion bars are out of the question with such a low floor, but in any case, extremely satisfactory suspension characteristics are obtainable with the coil spring type of arrangement. To obtain positive steering characteristics, a rack and pinion type unit is employed. A flexible coupling is incorporated in the steering column to damp out shocks and vibration.

So far as the body is concerned, its low lines minimize air resistance and give the vehicle an appearance that is characteristic of sports saloon cars. Although the body is designed to form a rigid box structure, the strength and stiffness of the base is adequate to support the vehicle satisfactorily without the help of the roof. Generally, chassisless construction is inherently stronger and stiffer than a separate frame and body combination.

Clutch and gearbox

A Borg and Beck, single-dry-plate clutch with a sprung centre is employed. The outside diameter of the friction lining is 8 in and its inside diameter is 5¼ in. Six pressure springs are fitted, and the spring load, assembled, is 990-1,050 lb. The withdrawal thrust ring is of carbon-based material and there is no compensating device or engine tie, since hydraulic actuation is employed. A bell-housing that is integral with the die-cast aluminium gearbox encloses the whole unit.

The four-speed gearbox weighs 67 lb dry. Its oil capacity is four pints, and S.A.E. 30 grade is recommended. Synchro-mechanisms are employed with top, third and second speeds. The ratios obtainable are: top 1:1, third 1·374:1, second 2·214:1, first 3·64:1 and reverse 4·76:1. A conventional type of floor-mounted gear shift lever is employed and gives positive control.

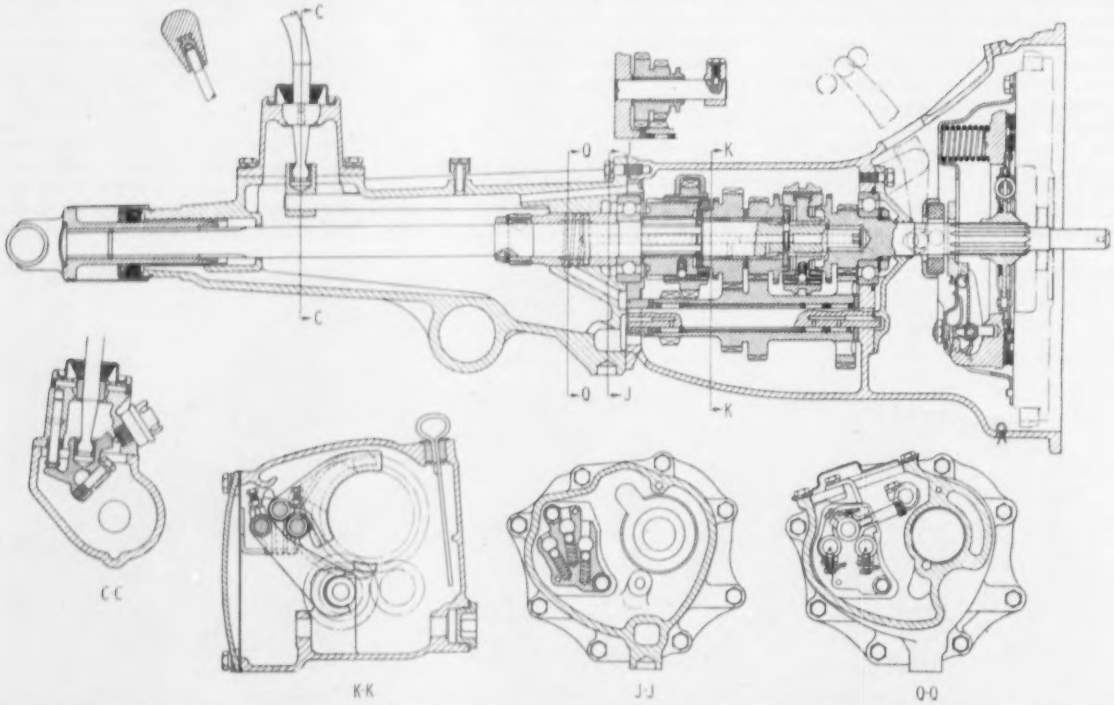
At the front of the box, a die-cast aluminium cover is bolted on to retain the primary shaft bearing. In it a scroll type oil return is machined in the bore through which the primary shaft passes. This cover positively locates the primary shaft assembly in the usual manner: that is, it retains a snap ring against a seating in a shallow counterbore round the bearing housing, and this snap ring is sprung into a groove in the outer periphery of the outer race of the ball bearing that carries the primary shaft assembly. The inner race of the ball bearing is pulled up against the primary gear by a ring nut, locked by a tab washer, on a 1⅛ in diameter thread on the En 361 primary shaft. This shaft is ⅞ in diameter at the spigot bearing at the front end, and 1 in diameter over the splines that carry the driven plate of the clutch. Integral with the front end of the gear and shaft are the cone and tooth ring for the first speed synchro unit. The tooth ring is $\frac{5}{16}$ in thick and the thickness of the primary gear is ⅞ in at the pitch circle diameter.

An En 361 mainshaft is employed; its overall length is about 24¼ in. This dimension is unusually large because the rear extension of the gearbox is long. However, the distance between the centres of the ball bearings in the front and rear walls of the gearbox is only about 7⅞ in. At the front, the diameter of the shaft is reduced to about $\frac{15}{16}$ in where it spigots into the 1¼ in long, needle roller bearing in the primary shaft. The bore in the primary shaft is about 1⅛ in diameter.

A simple cup-and-cone type synchro unit for the top and third speeds is mounted on the 1¼ in diameter splined portion of the mainshaft, immediately behind the spigot bearing. Three spring-loaded-ball detents, housed radially in the centre component, register in grooves in the En 18C sleeve component. The included angle of the cones is 20 deg and the mean diameter of the conical surfaces is about 2$\frac{5}{32}$ in for top and 2¼ in for third speed. Duravint bronze synchro-cups float in annular recesses, one in each end of the stamped En 18C centre component.

Three slots are machined radially in the material round each of the recesses. Projecting through them are lugs spaced 120 deg apart round the peripheries of the two synchro-cups. These lugs extend outwards as far as the roots of the splines in the sleeve member. To provide clearance for each lug and to form a V-shaped lead-in to centralize it in its slot after the synchronization, the ends of two of these splines are machined off obliquely at an included angle of 30 deg for a length of about $\frac{5}{16}$ in. The inner end of each lug, that is, the end facing towards the centre of the synchro unit, is chamfered to a V-shape to seat in the lead-in.

During the initial stages of gear selection, the sleeve, and with it the centre member and cup ring, are moved axially until the cup and cone engage. If the driving and driven assemblies are not synchronized, the cup is rotated



An outstanding feature of the Magnette gearbox is its lubrication system, by means of which all the principal bearings in the unit are positively fed with oil

through a small angle, which is limited by the clearance between the lugs and edges of their slots, and in this position the lugs baulk further movement of the sleeve. When synchronization has been effected, the chamfered edges of the lugs slide into the V-shaped seatings on the ends of the splines adjacent to them; thus they are centralized, so the sleeve can be slid into full engagement with the tooth ring of the gear.

The third speed gear, with its $\frac{5}{16}$ in thick integral tooth ring for the synchro unit, floats on a phosphor bronze bush. Its effective bearing length is $1\frac{1}{8}$ in, and the outside and inside diameters of the bush are respectively 1·3115-1·3120 in and 1·124-1·125 in. The bush is flanged inwards at its forward end and splines are cut in the flange to locate the component against rotation relative to the mainshaft. A $\frac{3}{8}$ in wide, oil groove is machined round its outer periphery, and a radial hole in the base of the groove allows oil, from passages drilled in the mainshaft, to pass through the bush.

Another phosphor bronze bush, behind the first, carries the second speed gear with its integral cone and $\frac{5}{16}$ in thick tooth ring. Separating the two bushes is a $\frac{5}{32}$ in thick phosphor bronze thrust washer with four slots cut in its inner periphery. Two diametrically opposite dogs are formed on the adjacent ends of each bush to register in these four slots and lock the whole assembly together: thus, neither the bushes nor the washer can rotate relative to the mainshaft.

Lubrication of the second speed bush is effected in the same way as that already described for the third speed bush, but the oil groove is $\frac{1}{2}$ in, instead of $\frac{3}{8}$ in, wide. Its inside and outside diameters are respectively 1·126-1·127 in and 1·3115-1·3120 in, and the effective bearing length is $1\frac{1}{8}$ in. This inside diameter is about 0·002 in larger than that of the third speed bush, which is the master component so far as location against rotation is concerned. To have made both bushes the same inside diameter, and therefore the same fit on the parallel shaft, would have introduced difficulties on assembly, since the second speed bush has to be pressed further along the shaft than the third speed one.

The second and third speed gear assembly is retained between two $\frac{3}{16}$ in thick, case hardened mild steel thrust washers. At the rear, the washer is divided diametrically and is fitted between the end of the second speed cone and a shoulder round the splines that carry the centre component of the synchro unit. The two parts of the ring are retained in position by the synchro-cup, which surrounds them.

A different method is employed to retain the front washer. This component is internally splined and is assembled from the front on to the splined end of the shaft until it is stopped by a spring-loaded plunger projecting from a radial hole drilled in the base of one of the splines of the shaft. Then the plunger has to be depressed so that the washer can move over it. At this station, a groove is machined round the splines, and the washer is rotated in this groove until the plunger springs up between two of the internal splines and prevents further rotation. Thus, the splines in the washer are half a pitch out of normal phase relative to those round the shaft, so the washer cannot move axially. The head of the plunger is chamfered so that a small screwdriver can be used to push it down to allow the washer to be rotated back again to dismantle the assembly.

The mean diameter of the conical face of the second speed synchro cone is about $1\frac{11}{16}$ in. As in the third and top speed assemblies, the cup is carried in a counterbore in the centre component of the synchro unit. The first speed gear is formed on the sleeve of this unit. There are three spring-loaded-ball detents in the centre component, which is allowed a limited axial float on the $1\frac{1}{4}$ in diameter splined portion of the shaft.

Location of the complete mainshaft assembly is effected at the rear ball bearing. The inner race of this bearing is mounted on a $1\frac{1}{4}$ in diameter portion of the shaft and bears against a shoulder formed at the ends of the splines that carry the centre component of the second speed synchro unit. Behind this bearing is a $2\frac{1}{2}$ in long, distance sleeve and the keyed-on En 1A speedo gear. The whole assembly is retained by a ring nut tightened against the speedo gear and locked by a tab washer. The distance sleeve forms a muff to help to carry the oil to lubricate the mainshaft. Details of this lubrication system will be given later.

The outer race of the ball bearing is carried in a circular housing, which is spigoted into a circular aperture in the rear wall of the gearbox. This arrangement has been adopted so that the whole of the assembly on the mainshaft, including the bearing housing, can be assembled in through the aperture in the rear wall. The bearing and its housing are retained by the rear extension casting, which is bolted on. Behind the speedo gear and its retaining nut, the mainshaft is 1 in diameter and splines are cut on its rear end to carry the sleeve of the sliding joint.

A felt dust seal and a lip type oil seal are housed, with the oil seal innermost, in a cupped, steel pressing assembled on to the rear end of the extension. To hold the assembly on, the rim of the cup is rolled into a groove round the extension. A tubular shroud, mounted in a similar manner on the sleeve component of the sliding joint, surrounds the seal housing. The sliding joint operates in a $2\frac{1}{4}$ in long $\times 1\frac{1}{8}$ in inside diameter, phosphor bronze bush. A noteworthy feature of this gearbox is that a small breather is screwed into the top of the extension so there is no possibility of oil being forced out by fluctuations in pressure due to the pumping action of the sliding joint, or to build-up of pressure internally as the unit warms up.

All the layshaft gears are in one cluster on the En 361 sleeve. This component is carried on needle roller bearings on the $\frac{3}{4}$ in diameter, En 352 shaft. There are three rows of needle rollers, one at the rear and two at the front. The reason why two rows of rollers are employed at the front, despite the fact that the loading is heaviest on the rear, is that by far the greater proportion of running is done on the higher gears, so both fatigue and wear tend to be greatest at the front. All the rollers

TABLE I. GEARBOX DATA

	Number of teeth	Diametral pitch	Helix angle	Material	Thickness of gear blank at p.c. diameter
Primary gear:					
Constant mesh	21	10·0231	33 deg 21 min 26 sec	En 34R	$\frac{11}{16}$ in
Dog teeth	30	10·8/15·45	straight	En 34R	$\frac{5}{16}$ in
3rd speed gear	25	10·0231	33 deg 21 min 26 sec	En 34R	$\frac{3}{8}$ in
2nd speed gear	31	10	30 deg	En 34R	$\frac{11}{16}$ in
1st speed gear:					
External	28	8	straight	En 34R	$\frac{5}{16}$ in
Internal	27	10·8/15·45	straight	En 34R	—
Layshaft cluster:					
Layshaft gear	30	12	33 deg 21 min 26 sec	En 34R	$\frac{11}{16}$ in
3rd speed gear	26	12	33 deg 21 min 26 sec	En 34R	$\frac{3}{8}$ in
2nd speed gear	20	11·547	30 deg	En 34R	$\frac{11}{16}$ in
1st speed gear	11	8	straight	En 34R	$\frac{5}{16}$ in
Reverse speed gear	—	8 (topped)	straight	En 18C	$\frac{5}{16}$ in
Reverse idler gear	—	8 (topped)	straight	En 18C	$\frac{1}{4}$ in

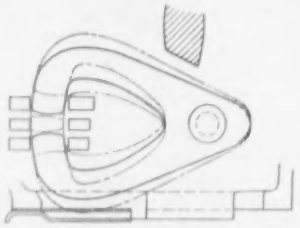
are ⅜ in long, and a wrapped, steel distance tube separates the front and rear sets. At each end, a $\frac{3}{32}$ in thick. case hardened En 18C thrust washer is interposed between the cluster and the end walls of the gearbox. The shaft is carried in holes in the end walls of the box and is located between the front cover and rear extension castings. At its front end, it is shouldered diametrically, by machining away a semi-cylindrical portion, and the remaining portion projects into a semi-circular hole in the front cover and thus is prevented from rotating.

The front end of the ⅜ in diameter En 32B reverse idler spindle is carried in a boss cast integrally in the base of the box and its rear end is in the rear wall. This spindle is locked at its forward end by a dowel-ended set bolt which is screwed radially through the boss and registers in a diametral hole in it. Pressed into the idler pinion is a phosphor bronze bush 1⅛ in long. The running clearance between the bore of the bush and the spindle is 0·003-0·0015 in.

An outstanding feature of this gearbox is its lubrication system. When the unit is static almost all the layshaft cluster is submerged below the oil level. Lubricant splashed through the primary gear bearing falls down into a space between the front cover and the front end of the box. Thence it passes into an axial drilling in the layshaft and out through radial holes to lubricate the roller bearings at that end of the cluster.

At the rear of the box, the other layshaft bearing is lubricated in a similar manner, except that this end is always submerged below the oil level, so it is not necessary to supply the space between the rear cover and the end wall of the box from above. This space forms part of the balancer duct that maintains the oil levels equal in the main part of the box and the rear extension. The positive feeding of the roller bearings with lubricant is a good feature since, despite the fact that they are below the oil level, they might otherwise be starved by centrifugal action.

Lubricant splashed through the mainshaft bearing at the rear of the box is collected in a space in the front end of the rear extension casting. From there, it passes up a $\frac{1}{16}$ in diameter duct to an annular groove in the bore of the casting, which houses the muff around the shaft. A spiral groove round the muff passes the oil forward to another annular groove, this time round the muff, and thence through a radial hole into a 1½ in long annular groove in the bore of the muff. From there, it passes through a radial hole into an axial one drilled from the front end of the mainshaft. As the oil passes forward along the length of the shaft, some goes out through radial holes to lubricate the second and third speed gear bushes and the remainder passes through a restrictor plug in the end of the shaft to lubricate the spigot bearing.



The ends of the arms of a C-shaped plate register in the striker forks so that only one gear can be engaged at a time

There are two subsidiary lubrication systems in the rear extension. One serves the speedo gear. A ¼ in diameter hole, drilled through the mainshaft bearing housing and the rear extension, breaks out of the casting immediately above the speedo gear. This hole slopes downwards towards the rear so that oil splashed into it runs down and drops on to the gear.

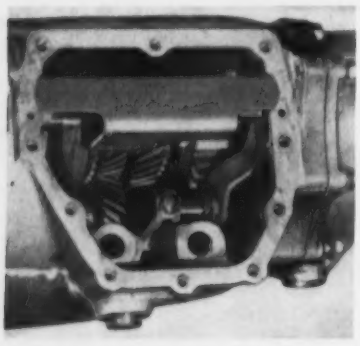
An overflow from the space behind the rear bearing runs into a trough that extends rearwards in the rear extension and feeds into a space immediately in front of the bush of the sliding joint. This ensures that, while the bush is adequately lubricated, the space in front of it is not flooded with oil, a condition which would lead to excessive quantities being pumped in and out of the sliding joint. A drainage duct is cored from the bottom of the space between the rear end of the bush and the oil seal, into the main chamber of the extension.

A turret for the En 3A striker lever is mounted near the rear end of the extension casting. On the lower end of the lever, a spherical head is formed, and round it is a phosphor bronze bush. This bush is in two semi-circular sections held together by a circlip in a groove round its outer periphery. It is housed in an En 3A fitting secured by means of a pinch bolt on the end of a remote-control rod. This fitting is positively prevented from rotating on the shaft by a Woodruff key.

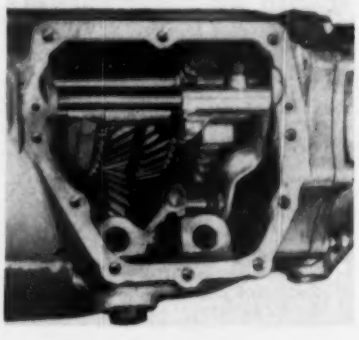
The rod is housed in the rear extension and its axis is parallel to the mainshaft. Its front end projects through a hole in the front wall of the extension casting. A plate bolted to the rear face of this front wall is drilled to carry the rear ends of the En 32B selector rods housed in the side of the gearbox and the spring-loaded ball type locks. Another striker lever, keyed on and secured by a pinch bolt, is carried near the front end of the remote-control rod. This lever projects in the usual manner into striker forks on the rear ends of the selector rods. These forks are secured to the rods by conical ended set screws inserted radially into their bosses to register in holes in the rods. This remote control layout is lighter, more compact and less expensive than the more usual separate control-housing arrangement bolted on top of the extension.

The interlock mechanism is somewhat unusual. In the rear extension casting, a C-shaped plate is arranged so that when the gear shift lever is in neutral, the ends of its arms project into the striker forks on each side of the striker lever. This plate is pivoted at a point to the rear of the forks, on a right angle bracket bolted to a lug on the casting under the pressed steel cover on top of the extension casting. Side-to-side movement of the striker lever turns the plate about its pivot and aligns the gap between the ends of its arms with one or other of the striker forks. When a gear is selected, the appropriate fork is moved into the gap between the arms of the plate, which is only just wide enough to accommodate it. Thus, it is impossible to select more than one gear at a time. A right angle bracket in the main body of the gearbox is slotted to form a gate, and tongues projecting down from the bosses of the striker forks register in the slots. The reason for the adoption of this interlock arrangement is that in other vehicles, this gearbox is used with a steering column gear shift control. With this type of control, the transverse movement of the striker lever is effected by moving the C-plate about its pivot. The reverse baulk mechanism is a spring-loaded plunger that bears against an arm on the fitting at the rear end of the remote-control rod. A cam on this fitting actuates the plunger of the reversing lamp switch, which is screwed into the side of the turret casting.

The front ends of the selector rods



Lugs project downwards from the selector fork collars into a gate assembled into the side of the gearbox



The gearbox with its side cover and gate removed to show the selector rods and forks

are supported in the front wall of the gearbox, and the selector forks are secured to the rods in a similar manner to the striker forks. The selector fork for top and third speed registers in a groove round the sliding member but that for second and bottom speeds is of channel section and fits round the first speed gear on the sleeve. All the forks are of aluminium bronze.

A die-cast aluminium cover bolted on the side of the box gives access to the selector mechanism, and a small pressed steel cover on top of the extension gives access to the striker forks. The oil level dip-stick is carried in a boss on top of the gearbox casing and the drain plug is below it. This gearbox arrangement is noteworthy for its compactness. The overall height of the gear assembly is about 6⅛ in, and its overall width, complete with selector rods, is approximately 6 in.

Rear axle

A Hardy Spicer propeller shaft, with needle roller bearing universal joints, transmits the drive to the rear axle. The shaft is 2¾ in diameter and its length between centres is 50·38 in. The axle is of the three-quarter floating, hypoid bevel type in a banjo casing. The oil capacity of the unit is 2¾ pt, and Hypoid 90 grade is recommended.

The B.S.1490-LM4-M gear carrier is secured to the banjo casing by ten $\frac{5}{16}$ in diameter bolts. In the nose piece, the axis of the case hardened En 35, 3 per cent nickel chrome steel pinion is offset 1 in below that of the crown wheel and $\frac{5}{32}$ in from the axis of the differential pinion. Two taper roller bearings, separated by a 2¾ in long, barrel-shaped distance piece, support the pinion shaft. The distance piece is a casting: it is less expensive than a drawn tube and its barrel shape gives it more resilience.

At the rear bearing, the shaft diameter is 1½ in; at the front bearing it is 1 in. The whole assembly, comprising the two bearings, distance piece and companion flange for the universal joint, is pulled against a distance washer, which seats on the front face of the pinion, by a nut on the ¾ in diameter threaded end of the shaft. This distance washer is fitted to clear the fillet radius between the spindle and the pinion, and it also is used to adjust the axial position of the pinion. It is made in a range of thicknesses in increments of 0·002 in, from 0·112 in to 0·126 in. The pre-load of the bearings is adjusted by tightening the nut on the front end of the shaft until the torque required to rotate the assembly is 11-13 lb-in without the oil seal, or 14-16 lb-in with the oil seal in position.

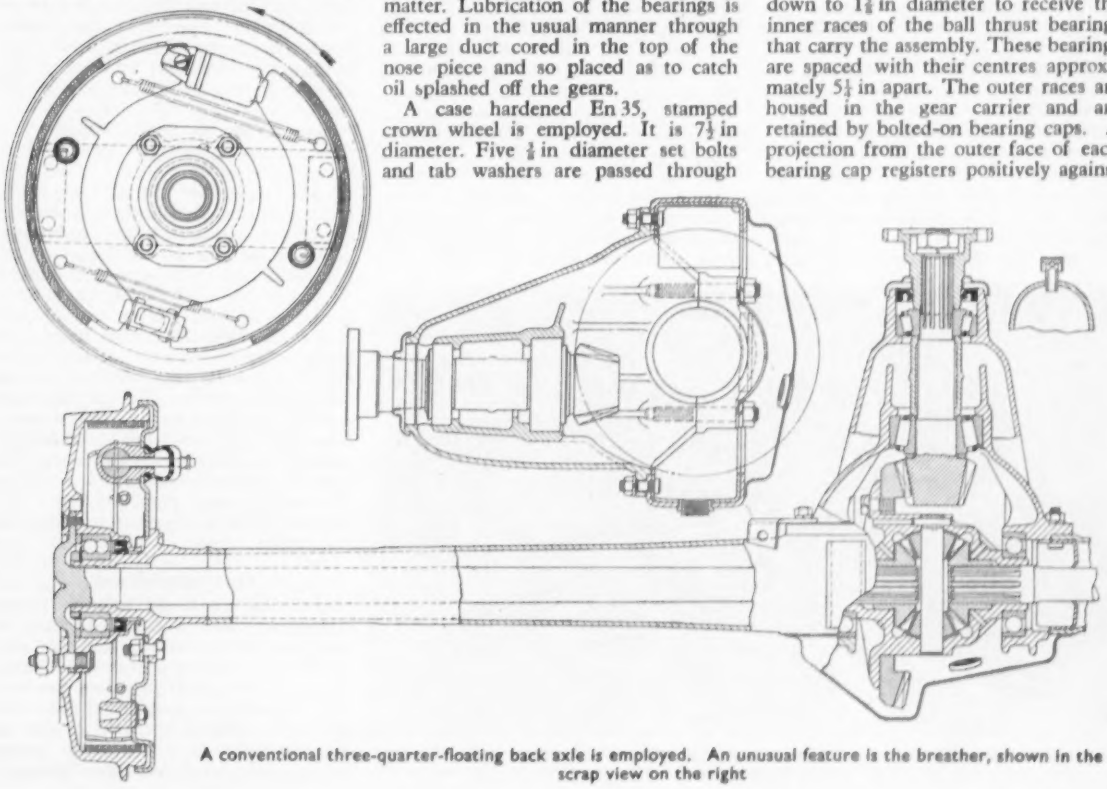
During assembly, the shaft, with the rear roller bearing on it, is inserted from the rear, the other components, including the front bearing, are then assembled from the front. The lip type oil seal is housed in the front end of the casting and its inner periphery bears on the boss of the companion flange for the universal joint. A cupped, pressed steel shroud is pressed on to the boss of the companion flange for the universal joint and surrounds the seal assembly to protect it from foreign matter. Lubrication of the bearings is effected in the usual manner through a large duct cored in the top of the nose piece and so placed as to catch oil splashed off the gears.

A case hardened En 35, stamped crown wheel is employed. It is 7½ in diameter. Five ⅜ in diameter set bolts and tab washers are passed through holes in the flange round the differential cage and screwed into the crown wheel to hold it in position. The B.S. 310/3 cast iron differential cage is in one piece. It is drilled to receive the ⅜ in diameter, case hardened En 36 nickel chrome steel differential pinion spindle. This spindle is located in the cage by a $\frac{1}{16}$ in diameter peg driven diametrically through one end. Flats are machined on it to pass oil outwards into the pinion bearings.

Spherical thrust washers of B.S. 407/2 bronze, in the quarter-hard condition, are interposed between the differential pinions and the cage. They are 2½ in diameter. The two pinions are of case hardened, En 36V steel, and the effective length of their engagement with the differential gears is approximately ¾ in. They are about 1⅛ in overall diameter.

Flat thrust washers of the same material as those for the differential pinions are interposed between the differential gears and the cage. These gears are of En 36 and are 2¼ in overall diameter. Their bosses bear for a length of $\frac{3}{16}$ in in the differential cage and are 1⅛ in diameter. The diametral clearance is 0·005-0·003 in. To assist lubrication, four $\frac{1}{32}$ in diameter holes are drilled through the cage and break through at points where the journal and thrust bearing surfaces meet. This practice is adopted by most manufacturers, but it is of interest to speculate as to whether or not the oil is centrifuged out of these holes instead of passed in through them to lubricate the bearings.

On both sides, the cage is machined down to 1⅜ in diameter to receive the inner races of the ball thrust bearings that carry the assembly. These bearings are spaced with their centres approximately 5½ in apart. The outer races are housed in the gear carrier and are retained by bolted-on bearing caps. A projection from the outer face of each bearing cap registers positively against



A conventional three-quarter-floating back axle is employed. An unusual feature is the breather, shown in the scrap view on the right

the end of the adjacent axle tube to prevent spreading. The mesh of the crown wheel and the bearing pre-load are adjusted to the specified values by means of shims between the inner races of the bearings and the cage. Baffle plates are fitted in the inner ends of the axle tubes to prevent excessive quantities of oil from passing outwards to the wheels. On top of the right-hand tube is screwed a small breather, exactly the same as that on the gearbox. This is a good feature, since it prevents oil being forced past the seals by internal pressure every time the axle warms up.

The axle tubes are about 2½ in diameter by $\frac{5}{16}$ in thick at their outer ends, where the hub carrier, with its integral brake back plate flange, is butt welded on. At a distance of 19¼ in on each side of the differential pinion centre, the pressed steel, spring seating pads are welded on. The half shafts are of En 17V, manganese molybdenum steel. They are 1¼ in diameter at their splined ends. The spline root diameter is 0·926-0·936 in and the depth is 0·080-0·090 in. Immediately outboard of the splines the shafts are reduced to 1 in and then are tapered out to 1¼ in diameter near their extreme ends.

A nickel chrome cast iron brake drum is secured by countersunk set screws to the upset driving flange on the end of each half shaft. These screws also retain the En 3A housing for the wheel bearing, which is pulled up against the inner face of the driving flange. The five, shouldered bolts that carry the wheels are threaded $\frac{7}{16}$ in diameter. They are pressed into holes in the flange round the bearing housing and pass through clearance holes in the driving flange and brake drum. To prevent them from rotating when the nuts are being tightened, their shanks, where they pass through the flange round the bearing housing, are milled.

The wheel bearing is of the two-row, staggered ball type. Its outer race is retained in its housing by the driving flange, which is pulled against a distance ring interposed between the two components. The inner race is pulled on to the end of the hub carrier by a ring nut threaded 1½ in diameter. An oil return scroll is machined in the bore of the hub carrier and, as the half shaft rotates in it, oil is prevented from passing out to the bearing, which is grease lubricated. Leakage of grease or oil into the brake drums is prevented by a lip type oil seal carried in the inner



The gear carrier assembly of the back axle

end of the bearing housing. This end of the housing is lipped to form a thrower and is enshrouded by a dished steel trap from which any lubricant that might escape past the seal is drained away to the outside of the unit.

Rear suspension

Semi-elliptic springs are used in conjunction with the through-axle of the rear suspension. There is no anti-roll bar, either at the front or rear, on this vehicle. A rubber bump stop is fitted under each longitudinal side member of the body-frame structure. In the full bump position, the axle tube bears directly on the rubber. The rear end rate of 144 lb/in gives a periodicity of 95 cycles/min. To the fully laden position, the travel is 3·88 in and to full bump it is 6·55 in. The unsprung weight is 125 lb per wheel.

A conventional spring mounting arrangement has been adopted. U-bolts round the axle clamp the spring between the lower plate and a pressed steel seating bracket welded under the axle. The inner edge of the lower plate is turned round the $\frac{7}{16}$ in diameter bolt that carries the rubber bushed eye at the bottom of the telescopic shock absorber. At the upper end of the shock absorber, another rubber bushed eye fitting is mounted on a similar pin welded in holes through a cross member of the body-frame structure. The shock absorbers are finned, for cooling, at their lower ends. Their centre-to-centre length is 12 in when in the compressed condition, and 19 in extended. Channel section rubbers, $\frac{5}{16}$ in thick, are interposed between the spring and its seating pad and retaining plate. Rubber is also fitted between the leaf retainer clips and the spring.

There are seven, 1¾ in wide, En 45A leaves in each spring. The first leaf is $\frac{7}{16}$ in thick and the remainder are ¼ in thick. Rubber pads are inserted between the ends of the leaves. The overall length between eye centres is 46 in, and the axle is mounted above the centre of the spring. Rubber bushes are employed in both spring eyes and also in the shackle pivot on the frame. The pins are of En 5C/R and are $\frac{7}{16}$ in diameter.

A Silentbloc bush is fitted in the front eye. It is carried between two ¼ in thick lugs, which are reinforced locally round the bolt hole by $\frac{5}{16}$ in thick washers. This reinforcement, of course, is necessary to increase the crushing strength of the material round the hole for the bolt. The lugs form part of, and extend down from, an overhung, two-piece box shape bracket welded to the side member of the body-frame structure. A $\frac{7}{8}$ in outside diameter ×16 S.W.G. mild steel tube is passed through the frame side member and the bracket, and is welded to both. This tube forms the main support for the bracket.

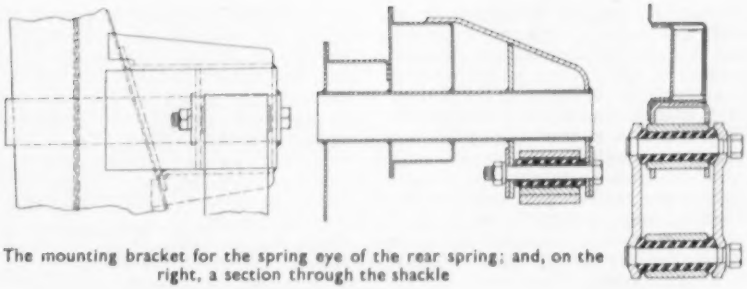
At the rear, a simple, inverted U-section bracket carries the shackle. Round the holes for the pins, the shackle plates are dimpled to pre-compress the rubber bushes. Doubtless this pre-compression materially increases the life of the bushes, since it offsets any tendency for tensile stresses to be introduced in the rubber during operation. An unusual feature of the assembly is that the shanks of the pins are milled near the heads and they are pressed into holes in one of the shackle plates. Thus, only one spanner is needed to tighten the nuts. The other end of each pin is shouldered so that when the nut is tightened, the plate is clamped against the shoulder. This arrangement positively limits the amount of pre-compression applied to the bushes.



Channel-section rubbers are interposed between the rear spring and its seating bracket and retainer plate

Front suspension

A double transverse link type front suspension, with a negative angle of trail, that is, an angle of lead, of 7 deg to clear the steering gear and engine sump, is employed; the cross member that supports the suspension is behind the sump. This suspension system is unconventional in that only the upper link is of the wishbone type; the lower



The mounting bracket for the spring eye of the rear spring; and, on the right, a section through the shackle

one is a single arm, of H-section. The differential loads due to brake torque are taken by two struts. One of these struts is attached to the outer end of the lower link and anchored to the body-frame structure to the rear of the suspension, and the other secured to a bracket near the outer end of the upper wishbone and anchored to the body-frame structure in front of the front suspension assembly.

At first sight, it is perhaps surprising that the lower strut is of $\frac{7}{8}$ in diameter × 10 S.W.G. tube, whereas the upper one is $\frac{3}{4}$ in diameter rod. However, there are two reasons for this. One is that the lower strut supports the single transverse link, whereas the upper one is attached to the wishbone, which is relatively stiff by itself and so requires less support. The other is that the drag loads are added to the compression loads in the lower link, but help to counterbalance those in the upper one. To have used a larger diameter solid rod instead of a tube would not only have increased the unsprung mass, but also, because of this increased mass, it would be liable to deflect under inertia loading as the suspension rises and falls. Such deflection is undesirable, since in most instances it would introduce an initial bow in the rod just when the compression loads due to drag are greatest.

One end of the tubular strut is inserted in a socket in the outer end of the lower link assembly; it is positively located by a pin, and is brazed in. At the other end of the strut, a $\frac{1}{2}$ in diameter threaded rod is brazed in to the tube to carry the rubber end-fittings and their retainers and the nut that secures the assembly. Two circular rubbers are employed. They are fitted one each side of the bracket to which the assembly is secured. A steel collar is fitted round the foremost rubber to stiffen it in compression. Both rubbers are spigoted into the holes in the bracket so that metal-to-metal contact does not take place between the bracket and the rod. The bracket is formed from two channel section pressings, placed back-to-back. To hold these two channels together, a strap plate is spot-welded to the flanges on each side. The upper edges of these plates are flanged and welded to the frame structure. To form a seating for the rubber, a circular rib is pressed in the metal round the hole through which the rod passes in each channel section.

A similar arrangement is employed at the front end of the upper tie rod, but the bracket on the frame is a single pressing and two separate seating plates for the rubbers are fitted one on each side of it. The rear end of this rod is swaged and drilled and is bolted between two lugs of a forked fitting mounted between the flanges of the front arm of the upper wishbone link. Apparently, the angular movement of the rods as the suspension rises and falls is insufficient to cause fatigue failure due to bending either at this point or on the front tubular tie where it fits into the socket in the lower link assembly.

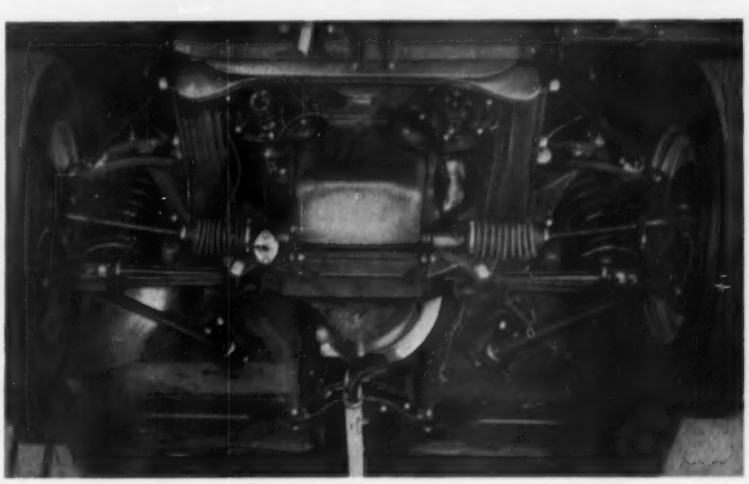
The centre of the rear attachment of the tubular strut is about $10\frac{3}{8}$ in behind the axis of the lower transverse link, while the centre of the front attachment of the upper strut is about $16\frac{1}{4}$ in, measured horizontally, in front of this axis. These positions, of course, were fixed mainly by practical considerations of the space available in the layout of the chassis. The angle the rear strut makes with the axis of the lower link is 40 deg, while that of the front strut from the vertical plane containing the axis of this link is 60 deg. Despite the relatively large rubbers employed at the ends of the ties, this arrangement gives a much more positive reaction to brake torque than is obtainable with more conventional double transverse wishbone systems. As a result, the accuracy of the steering geometry is maintained during braking, and the handling characteristics of the vehicle are better than would otherwise be possible.

Conventional coil springs are employed. Their rate is 184 lb/in. The rate at the wheel, including the effect of the rubber bushes, is 188 lb/in. This gives a periodicity of 94 cycles/min. The deflection of the springs to the laden position is $5\frac{13}{16}$ in and to full bump $7\frac{13}{16}$ in. Unladen, the static deflection is 4·14 in.

The spring is of En 15A, silicon manganese steel. Its free length is $14\frac{5}{16}$ in and its length, as fitted, in the fully laden condition is $8\frac{1}{4}$ in. The mean diameter of the coil is 4 in and the wire is 0·525 in diameter. There are $10\frac{1}{4}$ coils, but only $9\frac{1}{4}$ are effective. The upper end of the spring seats on a flanged ring, to which are projection welded the heads of the bolts that secure an inverted, flanged, cupped pressing bolted on top of the cross member to receive the upper end of the shock absorber. A doubling plate is fitted over the top of the cupped pressing. Two circular rubbers are employed in the end fitting on the shock absorber; they are spigoted into the hole through the pressing and doubling plate so that metal-to-metal contact cannot take place.

The shock absorber extends down through a hole in the spring pan. On its lower end, a rubber bushed eye is carried between two lugs, each of which is formed by a special head on an eye-bolt which, together with two more bolts, holds the lower spring pan down on a platform on the lower transverse link. A simple cupped pressing is fitted in the spring pan to provide the necessary radial location at the lower end of the spring. The 1 in diameter shock absorber is finned at its lower end to assist cooling. Its compressed length is given as $9\frac{7}{16}$ in to $8\frac{1}{4}$ in and the extended length is $14\frac{5}{16}$ in to $13\frac{1}{16}$ in.

A rubber bump stop is mounted under the frame cross member just inboard of the spring and bears directly on the lower transverse link. This link



The front suspension cross member and the steering unit are behind the engine sump

is sturdy enough to take the fairly heavy bending moments imposed on it as it strikes the bump stop. The rebound stop is incorporated in the shock absorber.

Two channel section pressings, $\frac{1}{8}$ in thick with $\frac{7}{8}$ in flanges, form the arms of the upper wishbone. They are about $2\frac{1}{16}$ in deep at their inner ends and $1\frac{5}{16}$ in at their outer ends, where the flanges are reduced to $\frac{7}{16}$ in and $\frac{5}{16}$ in overall width respectively, to enable a clean pressing to be obtained. At the inner end of each, a tubular boss for the rubber bush is welded into a hole punched in the arm. These bushes are of the parallel, as distinct from the conical, type. They are carried on the ends of a common pivot pin, which is passed through the cross member. Each rubber bush is in two parts, and is held between $\frac{1}{8}$ in thick dished retainers. These retainers are so shaped as to compress the bush into the boss when the nuts on the $\frac{3}{4}$ in diameter threaded ends of the spindle are tightened.

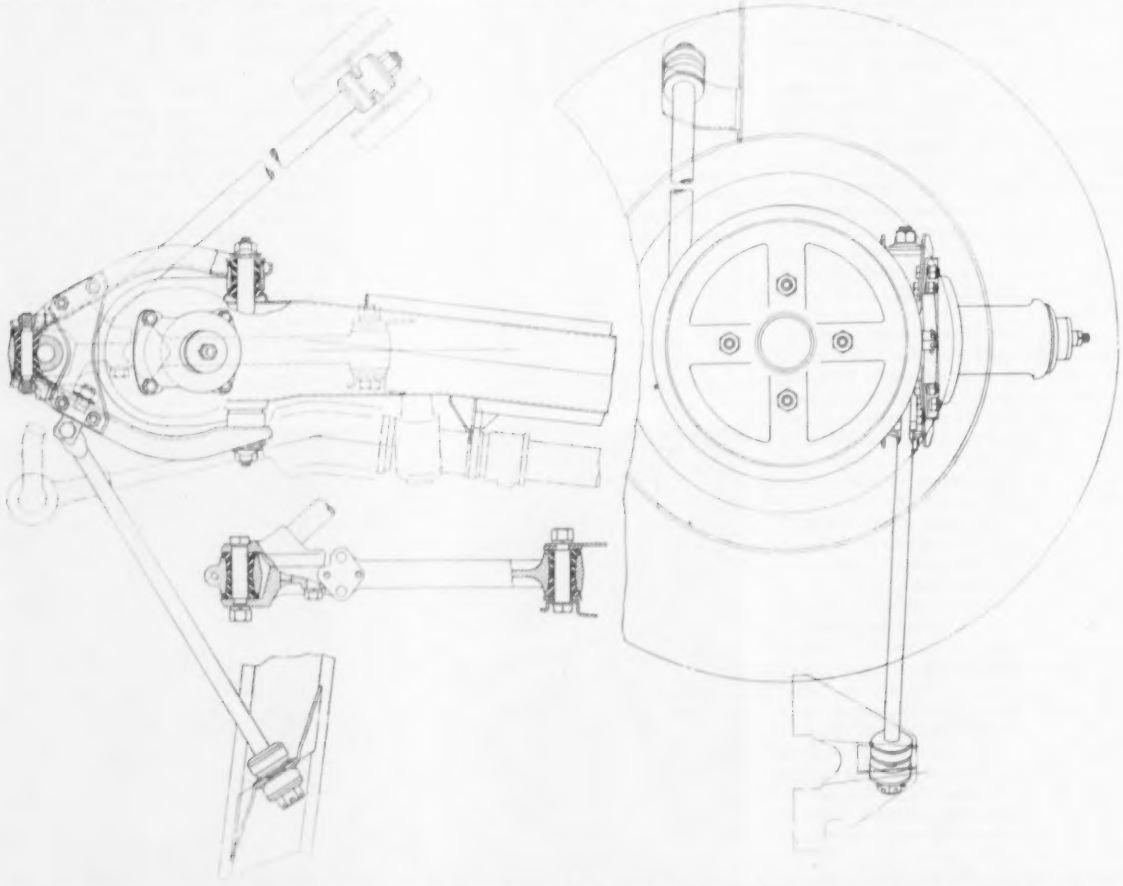
If flat retainers had been used, the excess rubber would have tended to be squeezed out of, instead of into, the bush. The pre-compression of the rubber offsets any tendency for tensile stresses to develop during operation, and therefore increases the life of the unit. A plain washer is interposed between the nut and dished retainer at each end of the spindle so that as the nut is tightened the retainer does not rotate and apply torsional pre-loading to the rubber. In the bearings, the pin is $\frac{13}{16}$ in diameter, but it is waisted to $\frac{5}{8}$ in diameter at the centre, where it passes through the frame cross member. It is shouldered at its ends to limit the amount of pre-compression.

At the outer end of the wishbone, a two-piece conical rubber bush is housed in an eye in a small En 3A forging assembled on to the swivel pin. The rubber bush is pre-compressed between the arms of the wishbone, and the $\frac{1}{2}$ in diameter pin is shouldered to $\frac{7}{16}$ in diameter to limit the degree of this compression. Both ends of the pin are threaded for the retaining nuts and spring washers. The two arms of the wishbone are held together near their outer ends by a $\frac{3}{16}$ in thick, pressed steel, channel section saddle bolted to their upper flanges.

The lower transverse link is a simple H-section forging. An eye at its inner end carries the two-piece conical rubber bush, in which is a $\frac{7}{16}$ in outside diameter distance tube. The pivot pin is $\frac{3}{4}$ in diameter. A hexagon head is formed at one end of the pin and the other is shouldered to $\frac{1}{2}$ in diameter and threaded to receive the retaining nut, by means of which pre-compression is applied to the rubber. The whole assembly is carried between two $\frac{1}{8}$ in thick lugs welded to the lower face of the frame cross member. Plain washers, also $\frac{1}{8}$ in thick, are interposed between the lugs and the rubbers. One of the two lugs is of channel section, and the head of the pin fits into it so that the nut can be tightened up without using a second spanner.

Near the outer end of the link is a platform on which the lower spring pan is seated. Immediately outboard of this, the link is forked, but is in two pieces. One piece is the main body of the link and forms one arm of the fork, while the second piece, which forms the other arm of the fork and the socket for the tubular strut, is bolted on and dowel located. A rubber bush assembly, similar to that at the other end, is carried between the arms of the fork. This bush is housed in an eye formed integrally with the lower end of the swivel pin. The head of the bolt that holds the assembly together is prevented from turning by a shoulder on the spot-face on which it seats.

As has already been stated, the eye for the outer pivot of the lower link is integral with the bottom end of the En 36 swivel pin. This pin is 0·8738 in diameter; the eye for the outer pivot



In the front suspension, struts are used to react the brake torque and drag loads. The side loads are taken by a light, pressed wishbone link at the top and a simple H-section forged link at the bottom

of the upper link is in a forging keyed on to a 2½ deg taper on its upper end. This forging is secured by a slotted nut on the ½ in diameter threaded end of the pin. The swivel pin bearings are housed in the knuckle between these two ends. They are of steel backed, lead bronze and both are 1¼ in long. The bushes are assembled one from above and the other from below into their shouldered housings and their centres are spaced approximately 9·59 in apart.

They are lubricated through two grease nipples. One is screwed into an axial hole in the lower end of the pin. The grease passes through this hole and out through a radial one into the lower bush. The other nipple is screwed into the side of the knuckle and the grease passes through it, directly into the upper bush. The thrust bearings between the upper face of the knuckle and the lower face of the upper eye forging is of the three-washer type. Two of the washers are of case hardened En 2 and are pegged, one to the knuckle and the other to the eye forging. A Compo washer is fitted between them.

Integral with the knuckle, immediately behind the lower swivel pin bearing housing, is an eye into which the 5⅛ in long, En 25W forged steel steering arm is inserted. The end of this arm is tapered and threaded for the nut which pulls it into the eye. Positive location against rotation is effected by a Woodruff key.

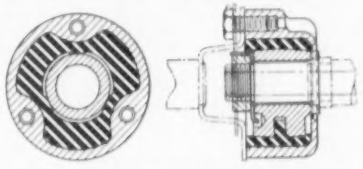
The stub axle is integral with the En 17T knuckle forging. At the inner wheel bearing it is 1·1812 in diameter and at the outer bearing it is 0·7875 in diameter. The two bearings, with a thimble-shaped distance piece between them, are assembled into the En 1 hub from each end, and the whole assembly is pulled on to the stub axle by a nut on the ¾ in U.N.F. thread on the outer end of the stub axle. A distance ring is interposed between the inner race of the inner bearing and the flange that carries the brake back plate. It is internally chamfered to clear the fillet. A lip type seal, housed in the inner end of the hub, bears on the periphery of this distance ring. At the outer end of the hub a pressed-in steel cap retains the grease and prevents the ingress of foreign matter.

A cast iron brake drum is spigoted and secured by countersunk set screws to a flange round the hub. The five, ½ in diameter wheel studs are secured to the flange in a similar manner to those on the rear wheels. Four lugs are cast near the outer periphery of each drum for balancing purposes. Unbalance can be the cause of serious vibration troubles and may adversely affect steering characteristics.

Steering

Positive control is given by the rack and pinion type steering unit, of M.G. design. A 17 in diameter steering wheel is employed. Its movement from lock to lock is 2¼ turns. On full lock, the inner wheel is at an angle of 30 deg 40 min and the outer wheel is 28 deg 50 min from the neutral position. The turning circle is 37 ft 6 in diameter.

A 1¼ in diameter ×20 S.W.G. tube attached to the dash carries the steering column. At its lower end, where the column passes through the toe board, a rubber gaiter effects the seal to prevent noise, dust and draughts from entering the body. Impregnated felt, split bushes, ¾ in long, are pressed into each end of the tube to carry the column, which is a 1⅛ in outside diameter × 7/8 in inside diameter tube, approximately 26½ in long. At the lower end of the column, a flanged, cupped pressing is welded on to form a companion flange for the flexible coupling.



Flexible coupling connecting the steering column to the pinion shaft

The coupling is of simple design and is noteworthy, since not only does it help to prevent the transmission of severe shocks to the steering column, but also allows for any misalignment due to flexure of the structure when traversing extremely rough terrain, such as is encountered in colonial countries. Moreover, assembly tolerances do not have to be maintained within such fine limits. The coupling is housed in a casting bolted to the flange at the lower end of the steering column. This cast casing is shaped internally to fit round a three-armed spider splined on the pinion shaft. Rubber is interposed between the spider and the casing, and the drive is transmitted from the spider, through the rubber, to the casing and thence to the flange. A nut on the end of the pinion shaft pulls the spider against split, tapered collet in a groove immediately below the splines. The split collet is retained in position by a circlip sprung into a groove round its outer periphery.

A three-piece, rack and pinion casing is employed. It extends the full width between points about 2¾ in inboard of the axes of the upper transverse links of the suspension system. The centre component is a 1½ in outside diameter tube. It is pressed into sockets in the inner ends of the two outer components, which are castings. One of these outer components houses the rack and pinion while the second serves only as a bearing for the other end of the rack.

Where the En 36T pinion shaft enters the casing of the rack and pinion unit, it is ¾ in outside diameter by ½ in inside diameter. A felt seal in a groove in the housing surrounds it at the upper end. The pinion is integral with the shaft and is near its lower end. Two En 32B thrust washers are fitted, one each side of the pinion; the upper one bears directly against the housing and the lower one bears against a bolted-on cast iron cover, which closes the lower end of the unit. The bore of this cover forms the bearing for the lower end of the shaft. A longitudinal groove in this bore distributes the lubricant over the bearing surfaces. A rubber sealing ring is fitted in an annular groove round the lower end of the bore.

The 1¼ in diameter rack is of En 8B and the teeth that are subject to most wear, that is, those adjacent to the centre, are flame hardened. Immediately opposite the centre of the pinion a spring-loaded plunger, housed in a thimble screwed into the casing, bears on the rack to hold it firmly in mesh. This helps to compensate for wear as it takes place, but its main function is to provide a measure of damping to help to prevent the transmission of shocks.

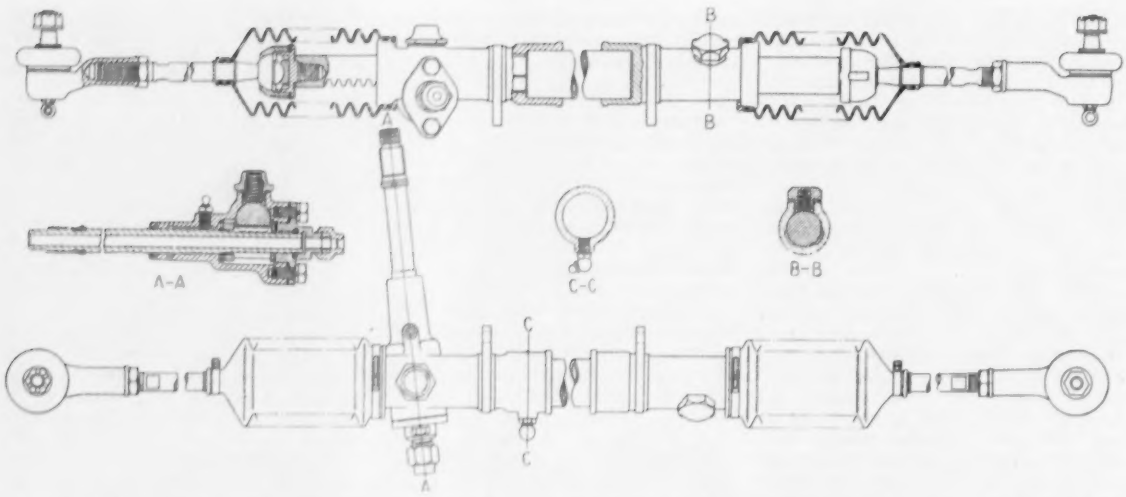
A second damper pad, of similar form, is screwed into the casing and bears on the other end of the rack. The ends of the casing are closed by rubber gaiters secured round them by clips and also clamped round the steering rods. Two lubrication nipples are fitted; one is on the pinion housing to lubricate the pinion and the other is on the adjacent rack housing to lubricate the rack, its bearings and ball joints.

The two-piece, cup component of a ball joint is screwed into a

TABLE II.

FRONT SUSPENSION DIMENSIONS

Swivel pin angle	6 deg	
Castor angle	+3 deg	
Camber angle	+1 deg	
Toe in	Zero	
	Upper	Lower
Length of links between centres	8⅛ in	12⅞ in
Inner bearings:		
Type	Rubber bushes	
Centre-to-centre spacing	5⅛ in	Single bearing
Horizontal distance from centre of bearing axis to chassis centre line	14⅛ in	9⅛ in
Vertical spacing	8⅛ in	
Pin material	En 3B	
Pin diameter	⅝ in	⅞ in
Outer bearings:		
Type	Rubber bushes	
Horizontal distance from centre of bearing axis to chassis centre line	22⅛ in	21⅞ in
Vertical spacing	9 3/16 in	
Pin material	En 3B	
Pin diameter	½ in	⅞ in



Rack and pinion steering assembly, with scrap views showing the spring-loaded plunger arrangements: one of these plungers holds the rack firmly in mesh with the pinion and the other simply helps to damp out road shocks and vibrations

⅜ in diameter tapped hole at each end of the rack. The balls are formed on the ends of the steering rods, which are more or less in line with the rack. With this arrangement it has, of course, been impossible to incorporate self-adjusting devices to take up wear. Therefore, shims are fitted between the two components of the cup. During assembly, the outer of these two components is passed over the steering rod and is screwed on to the inner one to pull the ball against the En 32B spherical seating housed in the inner component of the cup. The shims are fitted between the end of the outer component and a flange round the threaded portion of the inner one.

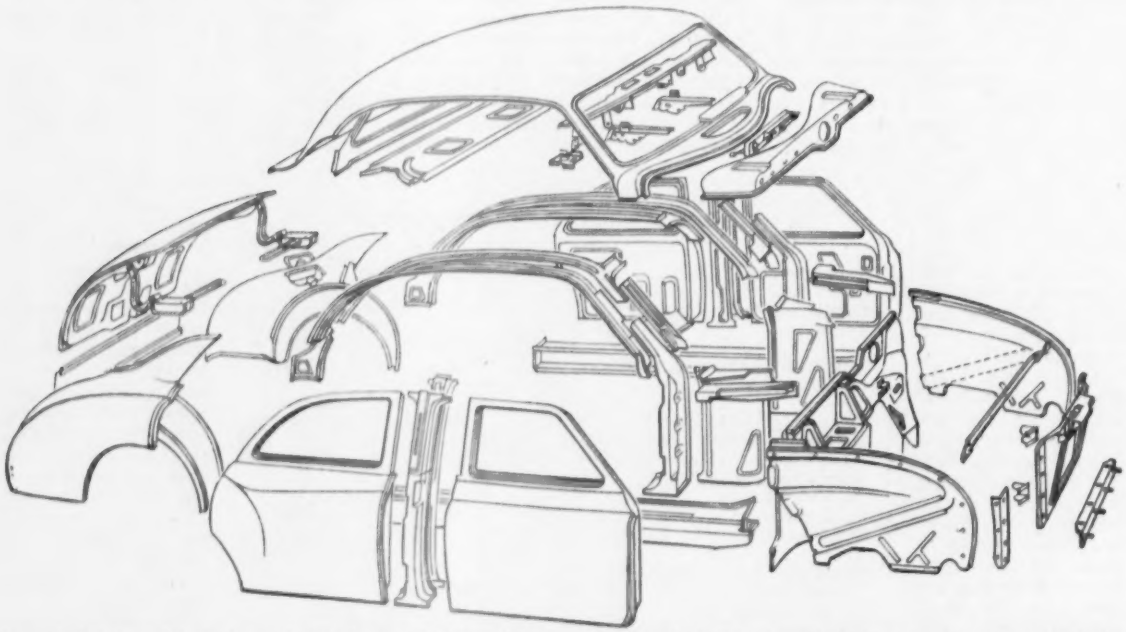
The steering rods are ⅞ in diameter and their outer ends are threaded to receive screwed on ball joints of the self-adjusting type. A lock nut on the threaded portion of the rod is tightened against the ball joint fitting. Two flats for a spanner are machined on the rod adjacent to the threaded end. These ball joints are lubricated through a grease nipple. Lubrication of the ball joints on the ends of the rack is effected during assembly and further attention is not required until adjustment, by removing the shims, is necessary.

Brakes

Lockheed hydraulic brakes are employed at the front and rear, with the usual mechanical hand brake arrangement to actuate the rear brakes for parking. A two leading shoe arrangement is employed at the front, while at the rear, a leading and trailing shoe layout is employed. The drums are of B.S.1452 grade 17, nickel chrome cast iron and are 10 in diameter. Slots are cut in the webs of the shoes to prevent squeal. The friction facing area is 134 in².

The pedal is of the pendant type with 6 in travel. Its lever ratio is 5 : 1. Compo, bronze bushes, 0·5665-0·5655 in inside diameter by 0·6705-0·6895 in outside diameter by 0·880 in long, form the pivot bearings for both the clutch and brake pedals.

The hand brake is of the pull-up lever type and is situated between the front seats. It is of the usual ratchet

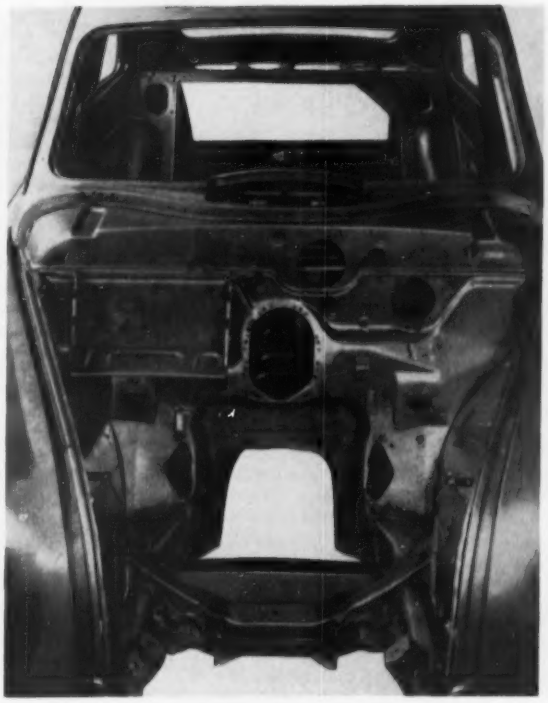


An exploded view of the body panels. The front end of the vehicle is stabilized by the bulkhead on which the radiator is mounted and also by the tie between the upper edges of the wing valances

type with a thumb button release at its end. The lever ratio of the handbrake is 7·3 : 1. A pressed steel yoke, the centre of which is pinned to the end of the cable from the brake control lever, forms the compensating device. The cables to each brake are, of course, attached to the ends of the yoke. All the cables are of the sheathed type.

Body-frame structure

The weight of the body, which is a rigid box-like saloon structure, is 760 lb, untrimmed and without seats. The main longitudinal members of the floor structure comprise a pair of side members cantilevered forward from under the dash to carry the engine and suspension, and two more side members formed by the body sills, which, at the back, are swept inwards to clear the rear walls. A number of cross members are ingeniously incorporated by making good use of the dash, toe board, heel board and floor panels. Another longitudinal component of the structure is the propeller shaft tunnel, which stiffens the floor and helps to carry the loads between the dash and the heel board.



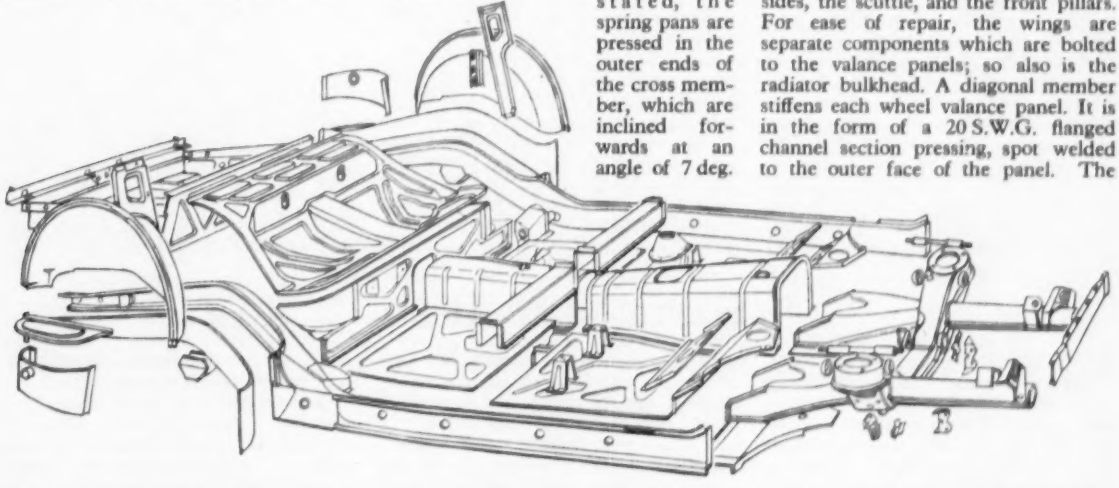
A view looking into the front end of the body structure to show the dash assembly

At the front, a 14 S.W.G. × 2½ in deep channel section cross member, with its 1 in wide flanges turned rearwards, is welded to the ends of the two cantilever side members. These cantilever members are of box section, formed by welding two 16 S.W.G. flanged, channel section pressings together at their flanges. Where they pass through the suspension cross member, they are about 3½ in deep by 3½ in wide over their flanges, but they are tapered to a smaller depth at their front ends. Welded on top of each are two brackets. One carries the engine mounting and the other the forward end of one of the brake torque reaction struts.

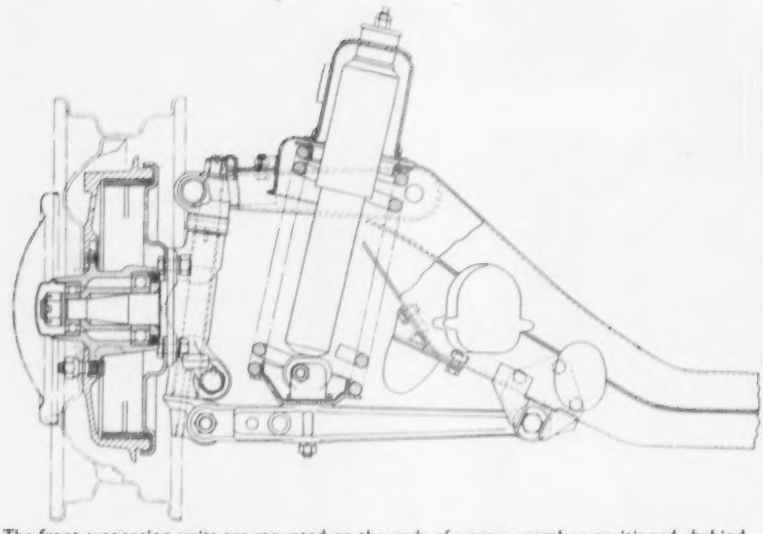
The 0·088 in thick suspension cross member is fabricated from two top hat section pressings welded together at their flanges to form a box section. At the centre, the overall depth of the member is 3 in and its width over the flanges is 4 in. As has already been stated, the spring pans are pressed in the outer ends of the cross member, which are inclined forwards at an angle of 7 deg. This sweep forwards has been adopted so that the centre of the member can be positioned further back to pass behind the sump, and also so that the rack and pinion steering gear can be accommodated immediately in front of it.

At the rear face of the suspension cross member, the lower channel section of the two that comprise each cantilever side member is terminated; the upper one is extended back under the toe board and splayed out to increase its width. Towards the rear, the top of this splayed out portion of the channel section is cut away and the upper edges of its side walls are flanged and spot welded to the 20 S.W.G. toe board. Its rear end is also flanged and is spot welded to the 2½ in deep riser of a step in the toe board. This step forms part of a cross member. It is completed by a 20 S.W.G. flat panel welded on, to continue the ramp of the toe board down to the floor, and by another flanged plate welded horizontally under the floor, between the sill and propeller shaft tunnel, and extending forwards to close the bottom of the flanged channel section that forms the rear end of the cantilever side member. The upper edge of the toe board is extended forwards horizontally and is spot welded to the dash. This provides the necessary space above the toe board for accommodating the pivots of the pendant pedals.

The other components that form part of the front end structure are the 20 S.W.G. bulkhead on which the radiator is mounted, the 20 S.W.G. wheel valance panels, dash panel and dash sides, the scuttle, and the front pillars. For ease of repair, the wings are separate components which are bolted to the valance panels; so also is the radiator bulkhead. A diagonal member stiffens each wheel valance panel. It is in the form of a 20 S.W.G. flanged channel section pressing, spot welded to the outer face of the panel. The



The body sills and propeller shaft tunnel form the main longitudinal members of the floor structure. Extensions of the sills carry the rear suspension, and the front suspension units are mounted on a cross member welded to two box section cantilever members extending forwards from under the dash



The front suspension units are mounted on the ends of a cross member positioned behind the engine sump

function of this member is to take the loads that otherwise would be carried by the lower edge of the panel, which is not stiff enough to do so because it is cut away locally to clear the suspension components.

At the top, the dash panel is flanged and spot welded to the scuttle. Its lower edge is spot welded to the flanged front end of the tunnel, on each side of which it is pressed to form a vertical channel section, of large cross sectional dimensions, to act as a buttress to support the two cantilever side members. The sides of each channel section buttress extend down on each side of each cantilever member to which they are spot welded. The wing valances, of course, are spot welded to the dash; the dash sides are separate panels, also spot welded on. There is no scuttle side panel since the wings extend back to the front pillars, which are of top hat section, spot welded to the dash side.

Sills of large cross section are employed. They comprise an 18 S.W.G. inner member, of top hat section, with its flanges spot welded to the 20 S.W.G. outer member, which is pressed to conform with the exterior styling and to form the door shut. The overall dimensions of this section at the centre pillar are 5 in wide × 5¼ in deep over the flanges. Forward of this, the sill section tapers in plan to about 8 in wide at the front pillar, but the depth remains constant. The cross section of the 20 S.W.G. front pillar is 3¼ in wide over the flanges × 3½ in deep, and that of the 20 S.W.G. centre pillar is 3¼ in wide over the flanges by about 2¼ in deep at a section midway between its ends.

Mid-way between the front and rear pillars, a cross member is formed by an 18 S.W.G. top hat section with its flanges spot welded to the floor and with its ends flanged and spot welded to the tunnel and sills. It is continued under the propeller shaft by an 18 S.W.G., short box section member, the ends of which are flanged and spot welded to the inner faces of the tunnel side walls. This member is, of course, cranked downwards at the centre to clear the propeller shaft.

Another cross member is formed by the 20 S.W.G. heel board, the ends of which are spot welded to the sills. Above the level of the sills its ends sweep to the rear to conform with the radius at each end of the seat pan and are attached to the rocker panel. The floor panel and the propeller shaft tunnel are in two pieces; both are of 20 S.W.G. sheet. They are divided on a transverse line adjacent to the centre cross member. At the front, the floor is pressed to form the riser and toe board, as already mentioned. All the floor panels, including that in the boot, seat pan and the heel board, are extensively swaged to prevent drumming. Swages are pressed round the propeller shaft tunnel in transverse planes so that it maintains its shape when it is removed from the press, otherwise there would be a tendency for it to spring open.

Immediately behind the heel board, the inner component of the side member on each side is swept inwards to clear the rear wheels. It is closed by a 16 S.W.G. plate bent to conform with the sweep. At the rear, a 16 S.W.G. bracket is welded inside the section, immediately above the point where the lugs for the spring shackle are welded on. Additional reinforcement is furnished, immediately behind the heel board, by the 16 S.W.G. bracket that carries the spring eyes. This bracket is of box section, spot welded to the inner face of the side member. Immediately outboard of the bracket, the sill section, where it is concealed by the quarter panel, is completed by a separate closing plate. A steel tube is passed transversely through holes in the sill and bracket and is welded in. Welded to the rear end of the sill is the closing plate of the inwardly swept section.

A 20 S.W.G. dished pressing forms the boot floor. Its front end is bent up to form a riser to which is spot welded the rear edge of the seat pan. This riser also acts as a cross member and carries the upper ends of the shock absorbers. Another cross member is formed by the rear skirt panel. The wheel arches, with the supports for the ends of the seat squab welded on to them, are attached to the flanges of the inwardly swept sill section.

Electrical equipment

Lucas 12 volt electrical equipment is used throughout. A GTW/9A 2 battery of 51 amp-hr capacity at a rate of 10 hours is employed. It is charged by a C39/PV2 dynamo operating in conjunction with an RB106/1 voltage regulator and cut-out unit. The system is protected by two 35 amp fuses, one for the horn circuit and the other for the trafficators and other auxiliaries. The contact breaker and distributor unit is the DM2 type with a vacuum operated automatic advance and retard mechanism. It is supplied from an LA 12, oil filled coil. Other electrical equipment includes WT 614 horns and SF80 trafficators. The lamps are P700 Mk VI headlamps, with 42/36 watt bulbs, 489/1 side lamps, with 6 watt bulbs, 469 tail lamps with 4 watt bulbs, L538 stop lamps with 6/18 watt bulbs.

PLASTIC METAL FILLER

A COLD setting plastic metal amalgum called "Hermetal" has recently been tested by the National Physical Laboratory. The manufacturers of this material, the Kenilworth Manufacturing Co. Ltd., of West Drayton, Middlesex, state that these tests have shown that Hermetal has exceptional adhesive powers. The amalgum can be used not only to fill dents, cracks, scratches or holes in metals, but also it can be employed to build up continuous flats or curves and to conceal rivets, screws or any kind of joint or seam, whether welded, spot welded, riveted, lapped or rolled. It can be applied to iron, steel, wood or glass, and to all non-ferrous metals including aluminium. When set, Hermetal is said to be as hard as lead, to take paint and to be non-shrinking, heat resistant, and water-, oil- and petrol-proof.

To keep the material in good condition, it is packed in two tins. One contains the powder and the other the solvent. This avoids wastage, since it is only necessary to mix enough material for the job in hand. The makers point out that Hermetal is primarily a filling medium and not an adhesive.

NOISE MEASUREMENT

Technique for Special Noise Problems

AN interesting article, "Measurement Techniques for Special Noise Problems" by G. L. Bonvallet and S. M. Potter, is included in the first issue of *Noise Control*, a new journal published by the Acoustical Society of America, of 57 East 55th Street, New York, 22. In the article the authors state that there are five important variables that have to be considered when measuring noise. They are: amplitude, frequency, directionality, distance, and time sequence.

To measure these parameters intelligently, it is necessary to know something of the capacity of the instruments used, since their characteristics govern to a considerable extent the techniques of measurement. The amplitude of the alternating air pressure generally encountered extends over a range of about 120 decibels (db). Few instruments are capable of covering accurately the whole of this range; therefore, it is necessary to have at least one microphone for the measurement of low intensity noise and another for high intensity measurement.

The relatively high mechanical impedance of microphones capable of measuring loud noises precludes the possibility of their being of sufficient sensitivity for quiet noises. On the other hand, a microphone for measurement of low intensity noises may be over-loaded and damaged by high intensity sounds. Equally important is the capability of the amplifier to handle, without modification, such wide ranges of noise. The dynamic range is limited at low signal levels by electrical noise or friction thresholds and at the other extreme by over-load. Linearity is a prime requisite of any instrument for noise measurement, since amplitude distortion creates a false picture not only of the amplitude but also of the frequency content of the noise.

In the majority of noise problems, the frequency range that is of most interest is between about 30 and 10,000 cycles/sec. The frequency response of the overall system, that is, the combined sensitivity at different frequencies of the microphone, amplifier, recorder and analyser, must be compatible with the type of noise to be measured. If the important frequency components of the noise are at either end of the spectrum, where equipment response is far from flat, either special calibrations or instruments specifically designed for this application must be used to obtain accurate measurements. Errors may arise not only from mechanical and electrical limitations of the instrument but also from the sound-field distortion caused by the size and shape of the microphone.

The directionality of the sound-field in the space surrounding a noise source can be measured by the tedious method of placing the microphone at a great many locations in turn. Choice of microphone location is one of the most important factors in the measurement of sound. A thorough understanding of how noise is propagated, reflected and refracted, together with a physical concept of how the noise is generated, is helpful in the elimination of unnecessary coverage of all the space around the source. If measurements are being made at a certain location and the sources are unknown, a directional microphone is useful in locating the sources. Moving any microphone towards suspected noise generators helps to pinpoint the important source since the noise level increases as the microphone approaches the source.

Distance between the microphone and the noise source is an important variable. It must be noted together with the data of amplitude since, under certain conditions, the noise level varies inversely with the square of the distance. If the microphone is placed too close to the subject, it responds to too localized an area and may not represent the important characteristics of the noise as heard from some distance. On the other hand, an outdoor microphone location too far from the source, in some instances, is equally bad, because atmospheric conditions may create a false picture of the radiation pattern as well as of the spectrum of the noise source. With both indoor and outdoor noise, the reduced intensity at a distance makes interference from other sources more serious and the greater area involved increases the number of measurements required. For most applications, a compromise in respect of source-to-microphone distance is necessary.

Variation of noise with time may be observed qualitatively on an indicating instrument. The mental integration of a fluctuating indication is an important part of measurement. Unless a proper technique, dependent on how the noise varies with time, is developed for the particular application, different observers may read widely different values. If the noise variations are very slow or very fast, recording instruments may simplify the problem. Analysis of transients involving milliseconds is brought within the scope of simple instrumentation by the use of a high recording-to-play-back speed ratio for frequency conversion.

Variation of noise with time may be due to changes in any one or all of the parameters involved, that is, amplitude, frequency, or directionality. This complicates the technique of noise measurement. Good judgment is needed in selecting the time interval in which readings or recordings are made, if significant data that adequately represent the time sequence are to be obtained.

Types of noise

From the standpoint of measurement technique, there are three general categories in which most types of noise can be classified. They are free- or random-field, pure-tone or broad-band, steady and variable. In a free-field, the sound emanating from the source has not been reflected. A reverberant field is one in which the noise has been reflected many times until it has an omni-directional characteristic. Noises produced out of doors at relatively great distances from reflecting surfaces are mostly of the free-field type, whereas those produced indoors with nearby walls, furniture and machinery are generally reverberant. There are exceptions to this, of course, such as in town or city streets, in which conditions are reverberant, and inside anechoic (echoless) chambers the condition is almost that of a free-field. In some applications, the field is neither random nor free. Microphone location and orientation are important, except under conditions of true random incidence. Calibration of the microphone is different for free- and random-field measurements, but this is discussed in more detail later.

There is an important difference between pure-tone noise, that is, of a single frequency, and broad-band noise, which has many different components covering a broad range of frequencies. It is that propagation and reflection of a pure-tone is conducive to standing wave patterns in bounded areas. With such patterns, steep gradients in sound pressure distribution complicate the selection of microphone location. When the noise in a bounded area is of the broad-band type, the effect of standing waves is small and the microphone position is not critical. For pure-tone measurements in rooms, remote indication is necessary. This is because, as the positions of the instruments and operators are changed, the normal room nodes also change and the pattern of nodes and anti-nodes alters. Remote indication is not necessary with broad-band noise.

Steady-state noise is defined as that which is constant with time and persists for a long period. Direct analysis is possible if the character of the noise does not change during the time required for the switching and tuning of frequency-sensitive circuits and the reading of indicating instruments. On the other hand, variable-state noise calls for considerable training and judgment to interpret the readings of a fluctuating meter. In many instances,

it is better to record noise of this type. Then it is available for study, without time limitations, by various analysing techniques, such as narrow-band, broad-band measurements and statistical methods. For one method of statistical analysis, a time exposure of the amplitude-frequency oscilloscope plot appears on a pseudo-percentage type analyser, which sweeps the audio-frequency band once per second. For special types of noise, such as impact, burst, or intermittent blast, the problem lies in interpreting rather than recording and analysing them. The difficulty of analysing noises of this type should not be under-estimated.

Special noise problems

The article then goes on to discuss a number of practical examples of measurement problems. These include measurements of noise reduction in a jet engine test cell, of noise of a passing truck, petrol engine noise, and of equipment such as business machines, refrigerators, fans, etc.

A typical problem in noise measurement is provided by small petrol engines. Directionality can be determined by a series of measurements, in octave bands, in a hemisphere round the source. Measurement of total power is carried out in a reverberant or reasonably reverberant room. If the noise level at the position only of an operator's ears is of concern, a simple measurement at that position is sufficient.

It may be necessary to eliminate exhaust and air intake noise by using suitable silencers and ducting the gas out of the noise field. In tracing the various sources of the noise, it may be helpful to drive the engine by means of a quiet electric motor. Analysis in octave bands may be too broad for some purposes and a narrow-band analysis may be helpful in obtaining information on the harmonic content.

So far as noise from other types of machines is concerned, it is difficult to specify which measurements should be made in a reverberant room and which in an anechoic room. When the total noise level has to be measured, the reverberant room is more useful, and equipment with inherently low noise output can sometimes be studied in such a room. If pressure levels at short distances, or directionality are required, a free-field space is needed.

Problems often arise when the noise source to be measured has some unusual characteristic. The frequency response of most measuring systems is questionable in the very low frequency region. By resorting to cavity calibrations of microphones and by the use of narrow-band analysers, these difficulties may be circumvented. Unless the room dimensions are much greater than the wavelength, standing waves are usually present in the room where this type of noise is measured. In these circumstances, a useful procedure is to use a number of microphones in different positions to determine the pattern of nodes and anti-nodes.

A problem that arises in the evaluation of fan and air conditioner noises is that if the microphone is placed in an air stream, the air velocities may be high enough to cause turbulence around it. This turbulence produces pressure fluctuations that may obscure the pressure variations due to noise. If the microphone must be placed in an air stream, it should be surrounded by a wind-screen. The problem is made more difficult by the fact that equipment of this type is usually relatively quiet, so that a poor signal-to-noise ratio exists.

Calibration of equipment

Microphones can be calibrated in three ways. The first is the pressure calibration, made in a coupler or other small chamber, where the sound pressure over the diaphragm is constant. Second, the free-field calibration is made out of doors or in an anechoic chamber, where the sound pressure at the microphone is mainly the direct sound from the source with no reflection from the walls. The third method is the random incidence calibration, in which the sounds impinging on the microphone come from all directions.

The situation is most satisfactory when a random-field calibration system is used and the noise is measured in a reverberant field, and when a free-field calibration is used and the measurements are made in an anechoic space. In the authors' experience, the calibration of most value to the exacting worker concerned with industrial noise is made in a random-field using broad-band noise, the spectrum of which contains all frequencies, and supplementing the sound level meter with an octave-band analyser. This calibration can be made in modern acoustical laboratories.

Conclusion

In their conclusion, the authors state that no treatment of measurement techniques for special noise problems is complete without mention of scepticism towards instrumentation and its results. This attitude keeps the engineer constantly alert to limitations and malfunctioning of the instruments. There is more to measurement of noise than simply reading the meter, and new noise problems have created a demand for new instruments and techniques. At the end of the article there is a useful bibliography.

PLASTICS EXHIBITION

THE third Plastics Exhibition and Convention organized by our associated journal *British Plastics* will be held at Olympia, London, from 1st to 11th June, 1955. There is a steadily growing interest in the automobile industry in the potentialities of plastics and there will be several exhibits, including complete bodies, of direct interest to the industry.

Several of the Convention papers will also be of great interest to those who are considering the employment of plastics materials in automobile manufacture. On 9th June there will be two papers on glass reinforced plastics, the material of greatest interest to the automobile engineer. At 10-30 a.m. "*Consistency in glass reinforced moulding*" will be discussed by Mr. J. Rees, of the Bristol Aeroplane Co. Ltd. and at 2-30 p.m. Mr. H. Silman, Engineering Research Centre, Birmingham, will discuss "*Glass reinforced plastics in automobile construction: their advantages and limitations.*"

Glass reinforced plastics can have properties that are of great interest to structural engineers, but it is felt that at present there is insufficient uniformity in the properties of glass fibre laminates.

During the past few years the relevant problems have been closely studied in the Plastics Department of the Bristol Aeroplane Co. Ltd., and Mr. Rees, who has been instrumental in the development of the process, intends to demonstrate how the difficulties of ensuring consistency can be successfully overcome.

Mr. Silman will discuss the use of reinforced plastics for automobiles. He will describe the available methods of construction, including wet-lay-up and pre-form moulding techniques. Cost considerations and problems of tooling and labour relation to mass production will be assessed. The trends in the development of glass fibre laminates will also be discussed, together with some of the problems to be overcome before increased utilization of the new technique can come about.

Free tickets for the Convention and Exhibition may be obtained from the organizers, *British Plastics*, Dorset House, Stamford Street, London, S.E.1.

The June and July issues of *British Plastics* will be devoted to the Exhibition and Convention. The June issue, which will be published on 1st June to coincide with the opening date, will contain a complete guide to the Exhibition. The July issue, which will appear on 15th July, will contain a review of both the Exhibition and the Convention. Each of these special issues for which there will be a great demand, will be published at the normal price 2s. 6d.

PROFILE-GROUND GEARS

Batch Production of Transmission Sets for Jaguar Cars

WHEN the Jaguar Company, more than seven years ago, decided to standardize a fully ground gearbox, the production of sets of gear components was entrusted to the Gear Grinding Co. Ltd. of Shirley, Birmingham. The association has continued to date. Being the manufacturers of the Orcutt gear-grinding and spline-grinding machines and ancillary measuring and gauging instruments, this firm was well-equipped for the work and possessed production facilities adequate to meet the then current and probable future supply requirements of the Jaguar Company. During this period the basic design of the gearbox has remained unchanged and minor modifications effected have in the main been dictated by manufacturing considerations. It has proved equal to all requirements, although the output of the Jaguar XK engine has been raised from 158 b.h.p. at 5,000 r.p.m. to 212 b.h.p. at 6,000 r.p.m. and the torque from 192 lb-ft at 3,000 r.p.m. to 218 lb-ft at 4,000 r.p.m.

The gearbox is laid out on straightforward lines and provides four forward speeds and reverse, with synchromesh engagement of top, third and second speeds. A detailed description was given in the July 1950 issue of the *Automobile Engineer*. Only the shafts, gears, and synchromesh mechanisms are produced by the Gear Grinding Company and the components are assembled in a cast iron casing by the Jaguar Company. In the past three and a half years the production rate on the standard gear set has been doubled and, currently, modified sets for the XK120 D special racing car are being produced additionally. There has, however, been no relaxation of the scrupulous care expended in production and inspection at each stage to ensure the maintenance of very high standards of precision. It was, in fact, interesting to compare the high quality of the Jaguar gears with aircraft gears being produced in the same shop. Anything short of complete consistency, it is held, will inevitably result in the occasional need to strip down an assembled box and adjust or replace components. This costly and time-wasting hazard, it is claimed, has been eliminated in the case of the Jaguar gearbox.

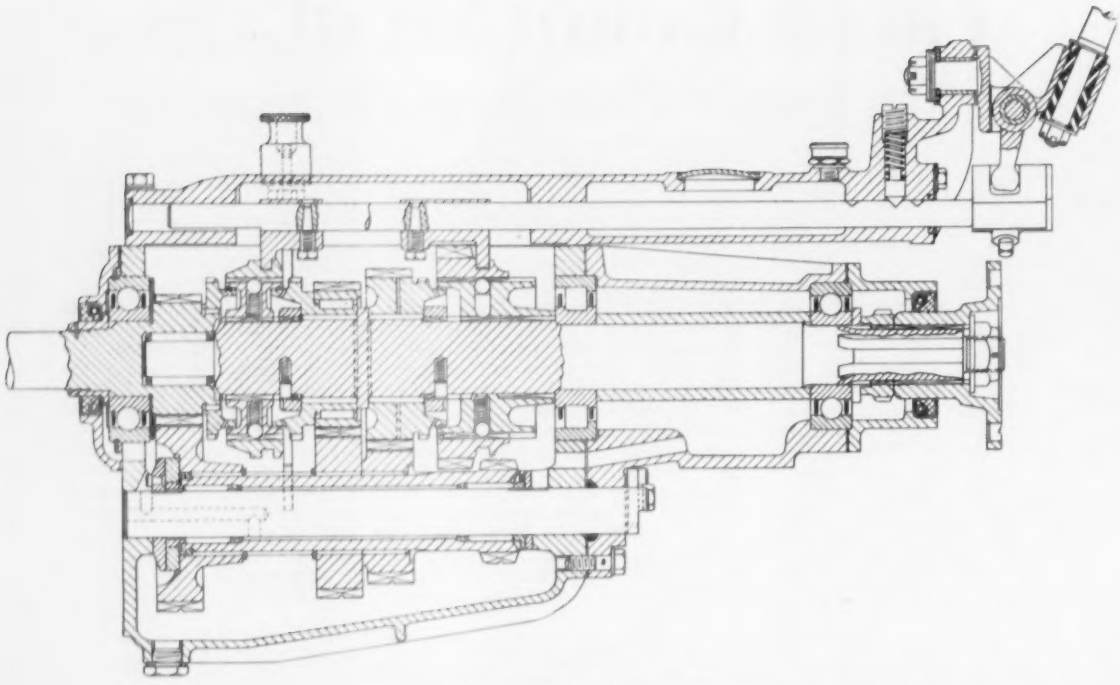
The production plant of the Gear Grinding Company is devoted exclusively to the manufacture and the grinding of gears; the building of the gear-grinding machines is carried out in a completely separate department. It comprises two large shops, one for production and the other solely for gear grinding. Since all classes of work are undertaken for a wide variety of industries, the production shop is laid out on "general" lines with the various machine tools grouped according to type. Groups of tools are arranged in transverse lines and the work is progressed longitudinally through the shop from group to group. In the gear grinding shop all machines perform a single finish operation, so there is no progression. They are grouped according to type,



The complete gear set, with primary shaft in position



Set of components produced for the Jaguar gear unit



Arrangement of Jaguar four-speed and reverse gearbox

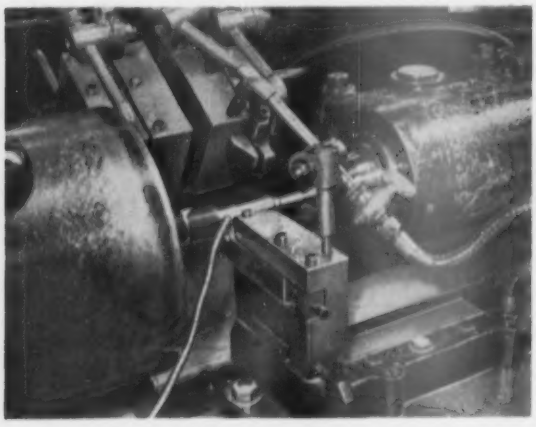
spur, helical or spline, and subdivided according to size and capacity.

All production operations, it is insisted, conform to orthodox good practice on standard machine tools. General machining and concentricity limits are held relatively close and a correspondingly good surface finish is maintained. These factors assume great importance in mounting accuracy for subsequent operations such as broaching and gear cutting. It is a maxim of the organization that "a good blank is an essential for a good gear."

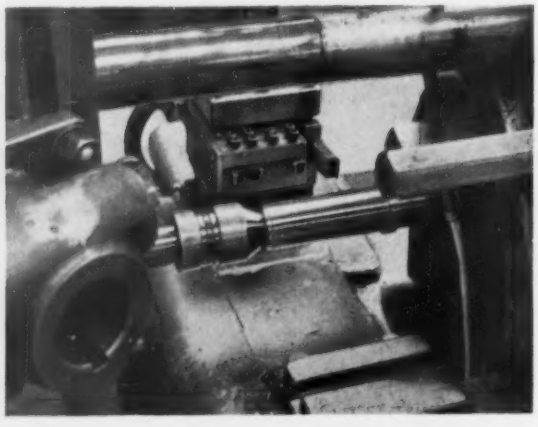
Machining

In the case of automobile gears in general, and the Jaguar gears in particular, there is little bar work except for shafts. Materials used are En36 for shafts and En39 for gears. Most gears are stampings or upset forgings, received in the normalized and annealed condition. Turning operations are performed on B.S.A. or Herbert chucking automatics or on Drummond, Herbert or Ward turret lathes. Usually two chuckings are sufficient but three may be necessary in some instances owing to the number of operations required to complete. Drummond turrets are used for the smaller items and Herbert No. 9 turrets for the larger work. Blanks are held to a maximum tolerance of 0·001-0·0015 in on the bore diameter and to 0·003 in on external diameters. Run out between the bore diameter and the blank face is checked by a dial indicator and must not exceed 0·002 in.

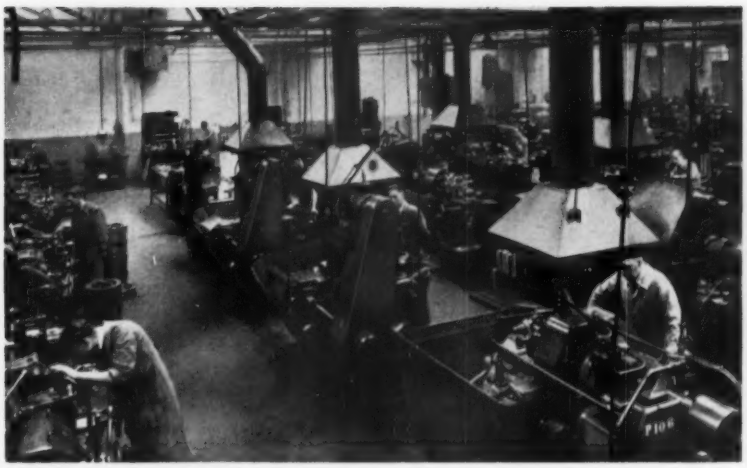
Bores are spline-broached on Rockwell (downstroke) and Electraulic (upstroke) vertical type broaching machines. Broaching can become a very expensive operation if, for instance, it results in the component running out of truth and thus requiring a second machining operation to correct. This is obviated by the use of hardened pressure plates ground with true faces. Both pressure plate and work are washed with coolant and wiped clean before each operation. No machining is done on the blank after broaching except to finish the diameter true to the major diameter of the splines. The blanks are initially left oversize for this purpose. Broaches are systematically withdrawn for resharpening after cutting a specific number of components. This number



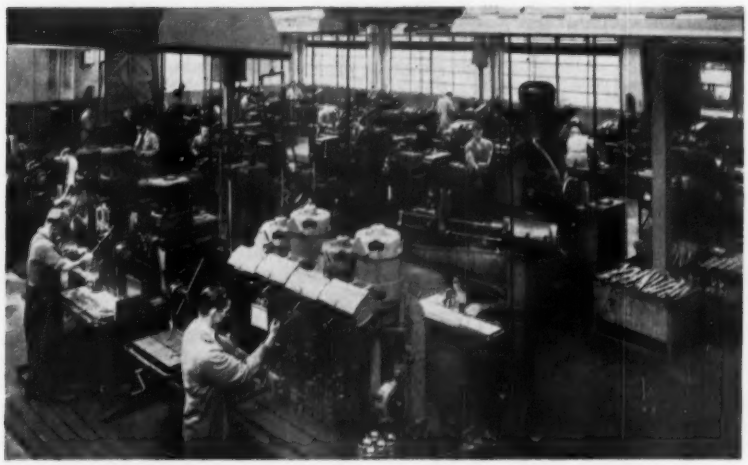
Primary shafts are form turned on a Smallpiece lathe



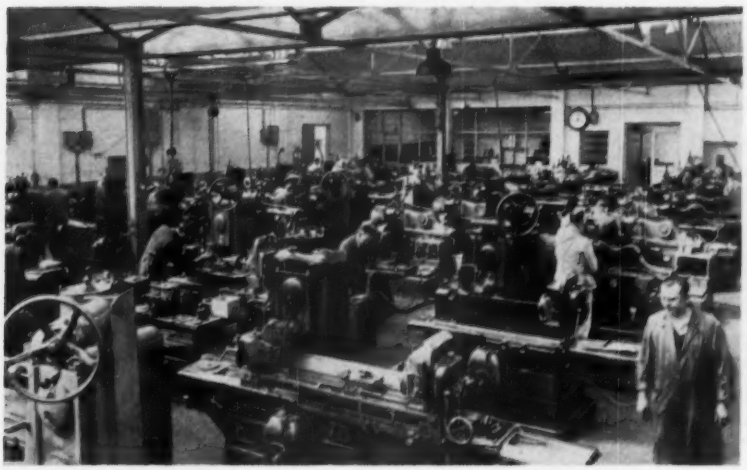
Ganged tools for grooving and undercutting the layshaft



General view of turning section in the production shop



Another section of the production shop—drilling, milling and grinding



Part of the gear-grinding shop—spline and spur grinders in foreground

is determined for economy against the number of components and the tool life. Regular inspection of broaches is made when the permitted number of components has been completed and at one or more interim stages.

For finishing the outside diameter of the blank a Herbert No. 7 machine is permanently set up with a common spindle to carry the special splined-sleeve mandrels for each component. Mounted in this manner the blank diameter is skimmed true to the top diameter of the splined bore and also, therefore, to the sides of the splines. The care expended on the production of the blanks makes it possible to cut the teeth on a truly concentric pitch line and also permits the minimum stock allowances to be left on the teeth for subsequent form grinding.

The primary shaft with its integral gear is machined on a Smallpiece copying lathe, reproduction being by a spring-loaded tool slide working against a profiled template. This machine is equipped with an air chuck and an air-operated back centre. For turning coned faces, and saucer-web walls on larger gears, a Herbert No. 7 turret is used. A spring-loaded follower on the back cross slide co-operates with a template mounted on the turret head.

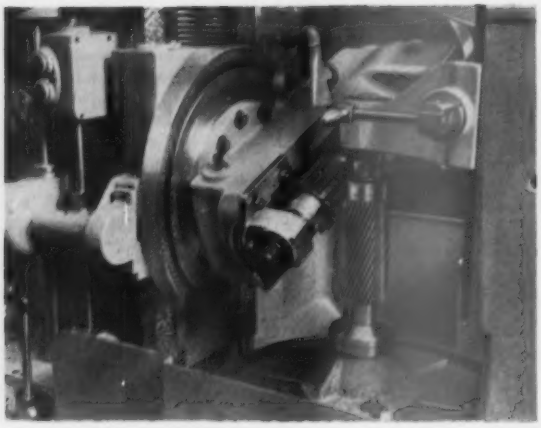
On the splined layshaft the gears are located and retained by circlips. This necessitates the provision of three grooves to receive the rings at a precise spacing. To ensure consistency, these three grooves, and also an undercut at the flange locating the 2nd speed wheel, are machined in a single operation by a gang of four tools mounted in a box on the cross slide of a Ward No. 7 turret.

Gear cutting

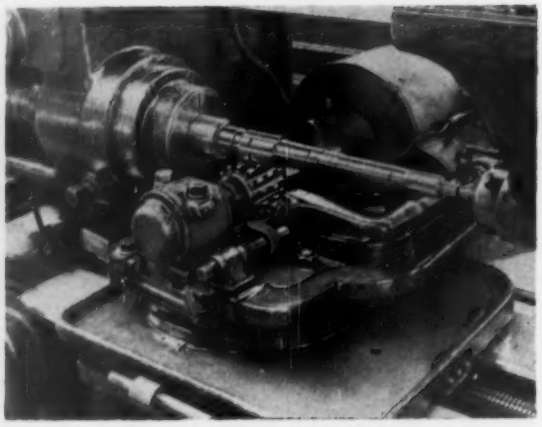
Gear cutting is performed with orthodox set-up on Barber-Colman and Pfauter hobbers, and Drummond Maxicut or Fellows shapers. Although ganging is employed where possible, according to the shape of the gears, excessive ganging is avoided as it may be liable to an accumulation of parallelism tolerances and consequently to springing of the arbor. The maximum number of plain slab gears to be ganged together is seven but generally the number is fewer.

Typical examples of Jaguar gears are: 1st speed wheel, external teeth, 2 off. Internal teeth, with peg cutter on Maxicut, 1 off. Constant mesh wheel, helical, 2 off. Top speed and 2nd speed cones, located on splined arbor, each 1 off.

On the 1st speed wheel in the latest Jaguar XK120 D gearset, the clutch dogs are sunk in a recess in the face of the wheel. They are cut on a Butler automatic shaper, being first roughed out and then finish cut. This machine is also used to relieve six of the internal teeth in the standard 1st speed wheel. The 36 longitudinal slots in the faces of the synchromesh cones, for oil distribution, are cut on a Hey nibbling machine. A duplex tool is used and the cone is indexed 18 times to complete



Gang of seven slab gears on a Pfauter hobber



Mainshaft splines are hobbed on Barber-Colman machines

in about 30 sec. Tooth ends of sliding gears and engagement dogs are rounded or chamfered on Hey tooth-rounding machines. Mainshafts and layshafts are splined on Barber-Colman spline hobbers.

Heat treatment

All components are pot-carburized in Birlec electric furnaces. The compound used is Etenite, in a ratio of 3 : 1 in reclaimed and new material. Pots are emptied over a grid and the compound falls through to a vibrating screen for the removal of debris. The screened compound is then blended with the fresh compound in a rotating barrel-type mixer and subsequently transferred to an elevated hopper. Pots of nickel alloy are of the non-sealing type with a flanged, registering lid. They are charged on a roller track and filled by gravity from the compound hopper chute. Two test pieces are included in each pot.

The temperature of each furnace is automatically controlled and recorded. Charts are marked with the job number, operation number, batch number, quantity, furnace number and date. These temperature records are held for two years in all cases, thus conforming to A.I.D. requirements. Test pieces are taken out at an interval of half an hour to each other, and are immediately quenched and broken for examination of the fracture. The four fractured pieces are tied up with a job record form and held in a store for a period of six months, or longer as appropriate.

Furnace temperatures are normally checked once monthly by the maintenance staff with independent instruments. A considerable amount of aircraft work is carried out and in this connection the furnaces are checked by A.I.D. personnel for each job.

Components of a shape liable to distort when quenched—the 1st speed mainshaft gear and top and 3rd speed operating sleeve are examples—are mounted over a "bung" and quenched on a Gleason press.

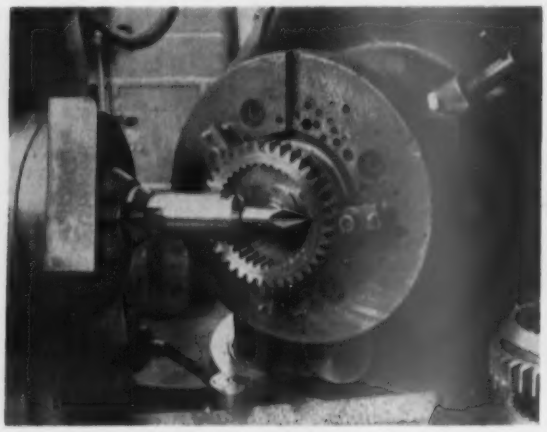
Grinding

After hardening, the end faces of gears are ground true and to size on Heald or Arter surface grinders with magnetic work tables. Gears are chucked on their outer diameters and ground in the bore on Heald 72A (Redhead) internal grinders. One of these machines is used to grind the two races for the needle roller bearings in the hollow layshaft. This is a special operation as the races are located one at each end of the shaft, which is approximately 7½ in long, and must be in axial alignment to within 0·0005 in. First the shaft is ground on the top of its splines for the full length of the work to 0·0005 in tolerance. A closely fitting sleeve is then fitted over the splines and this assembly is inserted into a pot sleeve on the workhead and the work clamped endwise. After one race has been ground to size, work and sleeve are withdrawn, reversed, and reinserted in the pot sleeve to bring the other race in position for grinding. Concentricity is thus ensured, as the bottoms of the splines, on which the gears centre, are subsequently ground true from the roller races.

On the mainshaft, diameters are ground to limits of size to −0·0005 in and parallelism to not more than 0·0001 in in 3 in on Norton, Jones and Shipman, or Churchill grinding machines. End threads, which are stopped off during heat treatment to remain soft, are ground on a Matrix thread grinder.

Gear grinding

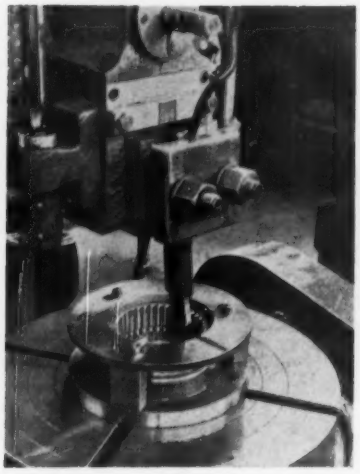
The work card issued for each job gives all the data required by the tool



Teeth and engagement dogs are rounded or chamfered on Hey machines



Grooving a synchromesh cone on a Hey nibbling machine



Relieving internal teeth of 1st speed wheel on Butler automatic-indexing slotter

setter. In the case of helical gears the machine is set up, indexed for one tooth, and one tooth is ground in each blank. These are then checked in the inspection room for correctness of lead and involute. If necessary, the setting is adjusted and teeth are ground until accurate lead and involute are established. The setter then completes his work and indexes the machine for the number of teeth in the gear. A gear, or a gang of gears, is then fully ground to an oversize chordal thickness and a further check is carried out. If proved, the gear is ground to the finished chordal thickness and a final check is made. If cleared after this check, the operator carries on, grinding one, two, or three gears on one arbor.

On the Jaguar gears the normal grinding allowance on the tooth chordal thickness is 0·008 in to 0·010 in. Usual practice is to feed in the wheel to depth by steps of 0·0025 in to 0·0025 in of finish depth and then make finishing feeds of 0·0005 in to size. This may involve 25 or 26 passes of the gear, and regularly three dressings of the wheel form are made. Norton grinding wheels of grade 60J, 8 in diameter and ½ in wide are used and the cutting oil is Vac-Mull, produced by the Vacuum Oil Co. The work passes through the shop in batches of 500 to 700 items and several machines may be set up for the same work. All machines, of course, are of Orcutt design and built by the Gear Grinding Co. It is the practice not to gang more than three helical gears.

Wherever possible, gears produced by the Gear Grinding Company are cut with protuberant hobs or similar design gear shaper cutters. By this means more economic use is made of the gear grinding machines, besides ensuring the maximum strength of gear teeth. These hobs and cutters prepare the gear teeth with little or no grinding allowance in the root. During the grinding operation, therefore, at the most a cleaning up of the root is all that is required. Every gear is checked in the inspection department, away from the machine. After checking, gears are gathered into batches and are then tested for noise by running dry with a mating gear, both freely and under a manually applied torque load, on a Red Ring noise-testing machine in a room insulated from the noise of the shop. To maintain continuity of testing, at least one gear from each batch is retained to serve as a "slave" for a succeeding batch.

JAGUAR GEAR DATA

Gear ratio, top	1·000 : 1
" " 3rd	1·367 : 1
" " 2nd	1·982 : 1
" " 1st and rev. ..	3·375 : 1
Pitch	10·86 D P
Pressure angle	20 deg
Helix angle, right hand ..	23 deg

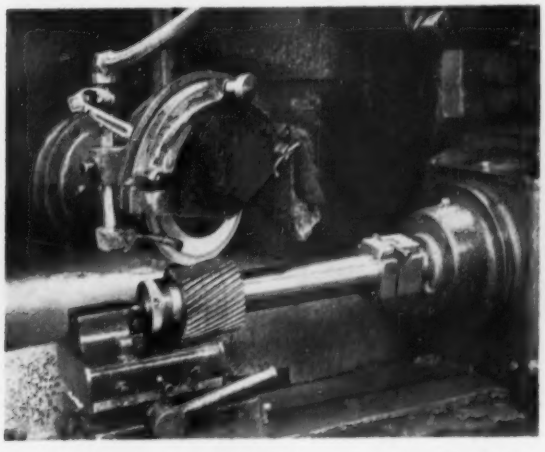
Shaft splines are ground on Orcutt machines, using Norton 60L grade wheels and Cooledge or Dixol soluble cutting oil as coolant. A harder grade grinding wheel is demanded to ensure the production of relatively sharp corners to the splines. The operators employed on this work set up the machines and also inspect the work.



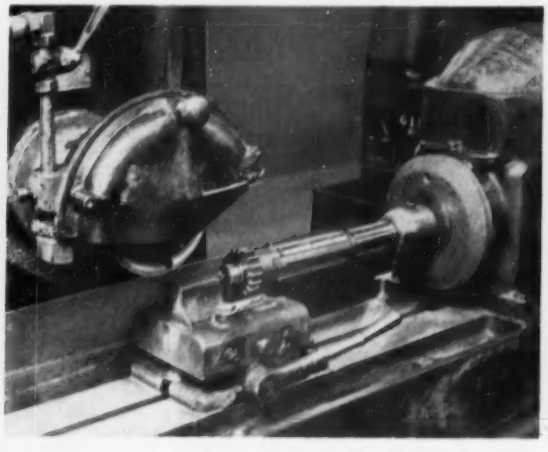
To obviate distortion, some gears are quenched on a Gleason press

The Company produces and grinds gear components, or grinds cut gears, for a number of other car manufacturers, and its capacity for helical and straight-tooth gear grinding and spline grinding is the largest in the country. Other manufacturing organizations, particularly those producing commercial vehicles, operate Orcutt gear and spline grinders, built by the Company, in their own works.

Whilst only a comparatively small number of car manufacturers use profile-ground gears, gear grinding is almost standard practice on heavy commercial vehicles, where power loading is much heavier. The Gear Grinding Company has done much to make gear grinding more economic, and it is interesting to speculate if, at some future date, it may succeed in widening the use of ground gears in the private car industry.



Gang of three 3rd speed layshaft gears on Orcutt helical gear grinder



Layshaft set up on its internal raceways on the Orcutt spline grinder

NEW PLANT AND TOOLS

Recent Developments in Production Equipment

AN endwise locating fixture, primarily for the location of crankshaft journals in their correct relative positions with regard to the grinding wheel, has been developed by The Newall Engineering Co. Ltd., Old Fletton, Peterborough. It is illustrated in Fig. 1. The fixture is wheelhead mounted, and consists of a bracket carrying a screw adjustment for lateral movement of the dial indicator assembly. This assembly incorporates a spring-loaded stylus which contacts the datum face of the component.

The fixture can be employed for left-hand or right-hand location. Only a zero position is shown on the dial indicator and the total movement of the indicator is restricted to three-quarters of a revolution. Therefore it is not possible for the operator to locate the work incorrectly by being a full revolution out of position. The illustration shows a fixture in the setting position. After setting is effected the fixture is swung through 180 deg.

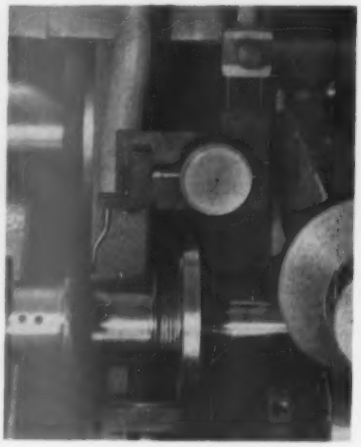


Fig. 1. Endwise locating fixture for crankshaft journals

(The Newall Engineering Co. Ltd.)

Profile millers

Interesting profile milling machines developed by Hayes Engineers (Leeds) Ltd., Gelderd Road, Leeds 12, are illustrated in Figs. 2, 3, and 4. The machine shown in Fig. 2 is the "Diemaster" universal die and mould milling machine. It is a small machine suitable for both tool room and production shop work to extremely close limits. For its size and capacity this machine is exceptionally rigid and has generous slides and ways, and robust nuts and leadscrews. All movements are hand controlled; they are indicated on large-diameter, dull chrome plated dials with 0·001 graduations.

The box base of the machine, which houses the motor and gearbox, carries the tray to which the machine column is bolted. The column carries the knee assembly on vertical ways and the overarm assembly on horizontal ways. A distinctive feature of the design is that the knee, underslide and table unit is counter-balanced by means of thrust-rods that pass through the machine tray and are connected by roller chains to a balance weight housed in the machine base.

Rack and handwheel pinion adjustment is provided for the overarm which can be secured in any desired position within the operating range by means of a powerful cam lock. The overarm has 7 in lateral traverse. A large vernier scale facilitates precise setting. The gearbox provides nine spindle speeds from 50 to 2,400 r.p.m.

The swivel head is mounted direct on the front facing of the overarm. It is arranged for movement through 180 deg. On the standard machine, the table size is 21 in $\times 6\frac{1}{2}$ in. It has 12 in longitudinal traverse, while the underslide has 5 in lateral and the knee 16 in vertical traverse. An oversize machine table, an 11 in diameter rotary table and horizontal milling and horizontal face milling attachments can be supplied as additional equipment.

It is also possible to have the "Diemaster" equipped with the Hayes Hydrotracer hydraulic copying equipment, see Fig. 3. Certain modifications to the basic machine are necessary, the chief ones being the attachment of a hydraulic cylinder for controlling the vertical movement of the knee and the fitting of the copying valve to the cutter head. Essentially, the equipment comprises a sensitive tracer unit coupled to a powerful hydraulic cylinder, both units being powered by a self-contained motor-driven hydraulic pump.

This Hydrotracer unit embodies a patented system of hydraulic control that gives very rapid reaction to change



Fig. 2. "Diemaster" universal die and mould milling machine



Fig. 3. "Diemaster" machine equipped with Hydrotracer copying equipment

(Hayes Engineers (Leeds) Ltd.)

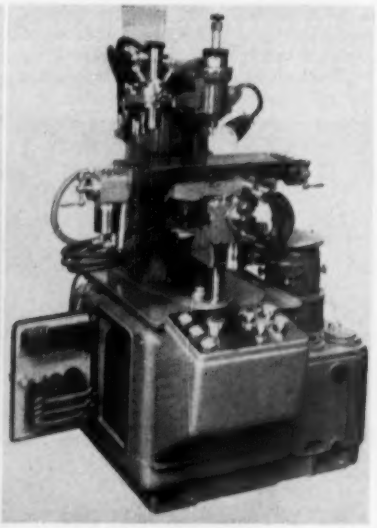


Fig. 4. "Tracemaster" fully automatic profiling machine

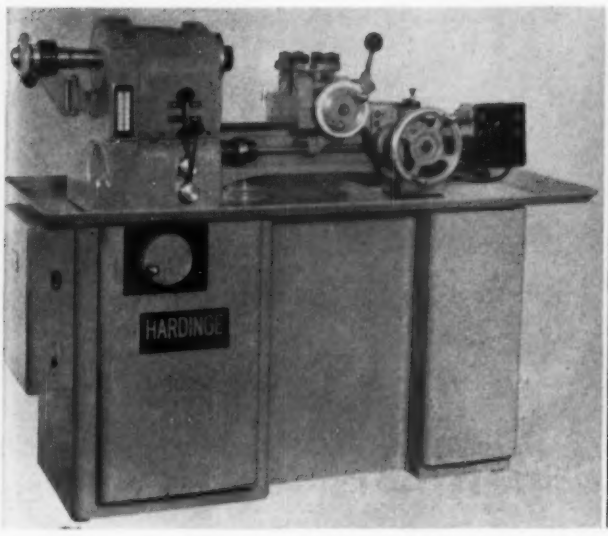


Fig. 5. H.C. chucking turret lathe

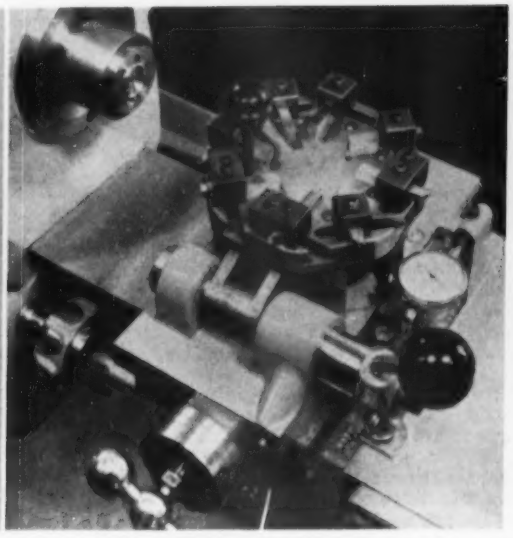


Fig. 6. The turret on the H.C. lathe

(Hardinge Machine Tools Ltd.)

in profile. A composite valve built into the tracer unit not only provides for following the contours, but also serves to eliminate static friction throughout the whole hydraulic system. This arrangement materially reduces the time lag in reversal of movement.

A development in connection with this equipment is the provision of a high speed air-turbine-driven spindle, which can be mounted in place of the milling machine swivel head. The spindle runs at 40,000-60,000 r.p.m. and is used in conjunction with precision ground carbide burrs for finishing dies and moulds.

A fully-automatic, hydraulic-traversing and profiling machine, the "Tracemaster" is illustrated in Fig. 4. The milling head on this machine is to the same design as the head of the "Diemaster." On this machine, however, the longitudinal traverse (12 in) and the cross traverse (6 in) of the table are driven by hydraulic motors which can be easily disengaged for manual operation. Vertical traverse is controlled by a 3½ in stroke hydraulic cylinder for automatic profiling; while for hand traversing there is a large diameter vertical screw fitted with a graduated dial. All traverse dials are graduated in units of 0·001 in. Final setting and increments of cut are applied through a worm drive.

In operation the vertical movement of the knee is controlled through the Hydrotracer. By means of a hand-operated valve, the rate of rise and fall of the work can be controlled to prevent overloading. Longitudinal traverse of the table is also controlled through the Hydrotracer, the traverse being increased or decreased automatically to suit the profile that is being machined. Speed is adjustable by means of a hand-operated valve, and direction is automatically reversed by a valve mounted on the underslide.

Cross traverse increments take place automatically at every reversal of the table motion. They can be increased or decreased by means of a manually operated valve. A hand-operated reversing valve makes provision for reversing the cross traverse so that forward or backward increments of traverse may be employed. In addition, adjustable limit-stops disengage the traverse on either forward or backward motion at predetermined positions; traverse in both directions can be isolated by means of a master hydraulic cut-out valve.

Chucking turret lathes

Two chucking turret lathes, designated HC and HCT respectively, have been added to the range of precision machines manufactured by Hardinge Machine Tools Ltd., Hampton Road West, Hanworth, Feltham, Middlesex, a subsidiary of Sheepbridge Engineering Ltd., Chesterfield. The specifications are the same for both models, with the exception that the HCT model embodies a production threading unit which is not included in the HC specification. An HC machine is shown in Fig. 5. These machines have been specifically designed for medium quantity batch production on precision work. To allow this to be carried out economically, one of the main design objectives has been to provide cheap and rapid setting-up.

The Hardinge extreme precision headstock spindle fitted is of large diameter and is carried in widely spaced bearings. It is driven through a variable speed unit that gives steplessly variable speeds from 125 to 3,000 r.p.m. A Hardinge bed assembly, topped by a single flat hardened steel plate with undercut vees, is employed. The total bearing of headstock and carriage on this flat plate is 175 in². Incorporated in the carriage is a power-feed feature that gives steplessly variable longitudinal feeds from ¼ to 10 in per minute.

A unique turret arrangement is employed. There are eight turret stations. They are designed to take standard commercial carbide or high speed steel tool bits, a feature that ensures minimum first cost for tools and in addition simplifies setting up. As many as 12 to 16 tool bits can be used in a single set-up. This multiplicity of tools, combined with the feature of carrying the turret on the cross slide, makes it possible to machine completely at one setting, parts that entail a considerable number of different operations. The turret and cross slide design is such as to ensure complete accuracy between turning, boring, undercutting and facing operations.

Each turret station has independent tool adjustment by means of an adjustable hardened screw, so that the tool or tools in one station can be set and adjusted to the final precision cutting size without affecting the tools at the other stations. Accurate turret indexing is ensured, since the position at each station is fixed by a lever operated by a hardened and ground taper binder directly contacting the rounded ends of the adjusting screws. The turret, shown in Fig. 6, is mounted on high precision, large-diameter, angular contact ball bearings.

The threading attachment, for the HCT model only, is so designed that with one lead screw and follower and a cheap ⅜ in square tool bit, any diameter thread of the same pitch can be cut at high production speeds. Large expensive dieheads, collapsible taps and chasers are not required. Through the use of the automatic thread control unit, threads can be cut up to a shoulder or into a bottomed hole. At a predetermined point, the control unit releases the follower from the lead screw and lifts the threading tool from the work. On release, the attachment returns to the starting point of the thread. An important standard feature on both

models is the Hardinge quick-acting collet closer. This attachment takes standard Hardinge 5C collets or internal or external step chucks.

Gear hobber

A significant advance in gear production has recently been made by Michigan Tool Company, Detroit, Michigan, U.S.A. Briefly, the development consists in equipping the new Model 1445 universal ultra-speed gear hobber with automatic loading and unloading devices and with a Michigan 3-way gear classifier for monitoring every gear produced. One of these machines so equipped is shown in Fig. 7.

The machine itself is a single-spindle hobber that will hob up to 8-pitch spur and helical gears of diameters up to 5 in and face widths up to 4 in. It can be used for helix angles up to 45 deg right- or left-hand. The hob is plunge-fed into the work, and the work rotates at a pre-set, timed relation to the hobbing tool. The complete hobbing cycle is automatic, with the machine returning to the loading position on completion of a workpiece. Either conventional or climb hobbing may be used with single-, double-, or triple-thread hobs.

This machine incorporates an entirely new design of head with three separate adjustments; they are hob thread angle, gear helix angle and hob position shift. To allow these separate adjustments, the head is made in four sections. The main section is mounted on a vertical swivel plate integral with the main column. At this point the required right- or left-hand helix angle is set on a vernier scale adjacent to the swivel plate. The next section functions as the hob cross-feed section. Movement of this section in relation to the main section is effected by means of a hydraulic cylinder mounted on the main section. The third section is joined to the second by means of another swivel plate graduated for movement up to 15 deg right- or left-hand. Hob thread angles are set on this scale. The final section carries the hob spindle and is linked to the preceding section by sliding ways. Automatic motion on these ways, hydraulically actuated, positions the hob for pre-selected increments of shift over a total movement of 3 in.

This novel head design greatly simplifies set-up in changing from one type of gear to another, since different gear helix angles are merely "dialled" on the hobbing spindle head. Cross-feeding at the desired helix angle by means of this adjustable head eliminates the need for ratio calculations and extra change gears customarily required for pre-setting the correct relative motion between the hob and the workpiece.

Two other factors contribute to the high output possible from this machine. They are: the plunge feed action of the hob and the automatic work-holding tailstock. Hob shift can be effected either manually or automatically. For manual operation there is a push button control for shifting the hob the desired number of pre-selected increments at the appropriate point in the production schedule. For automatic operation, the hob shifter control is pre-set for shifting

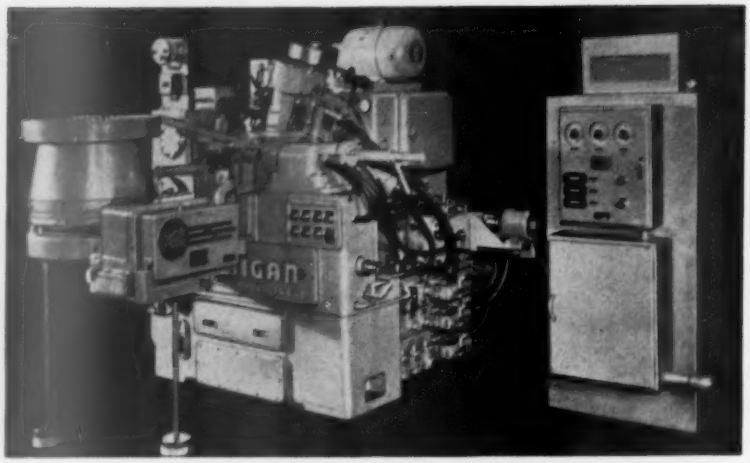


Fig. 7. Michigan universal ultra-speed gear hobber with automatic loading and unloading devices and automatic inspection equipment
(Gaston E. Marbaix Ltd.)

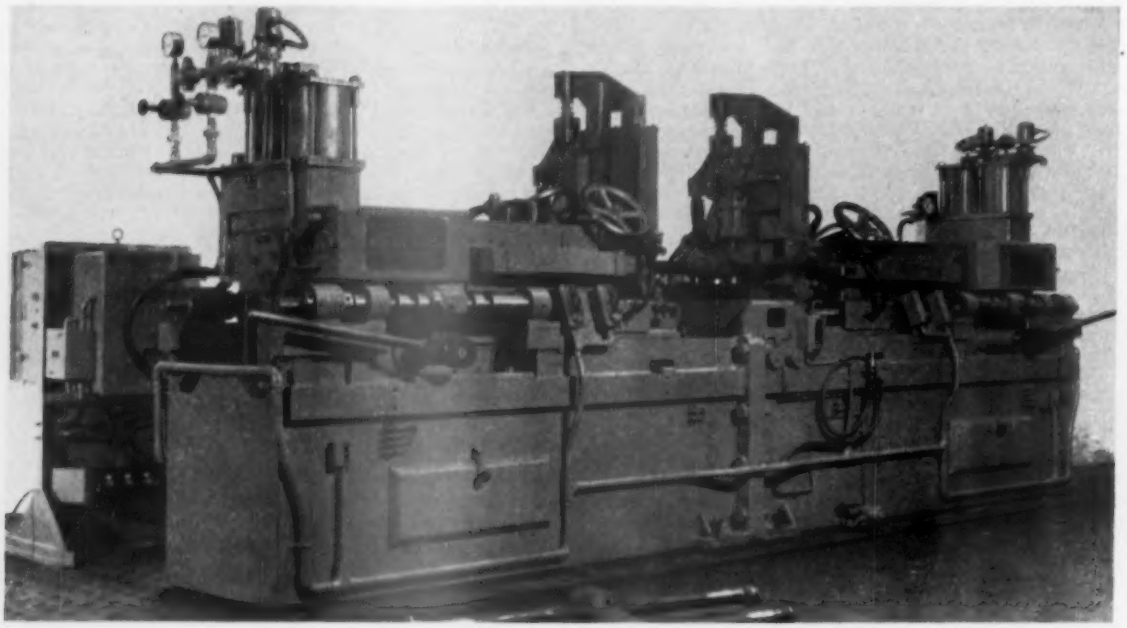


Fig. 8. Double-ended automatic flash butt welder for automobile rear axle cases
(A.I. Electric Welding Machines Ltd.)

the desired amount at the completion of each cycle. A warning light flashes after the hob has moved through the full distance of the hob shift travel.

Because of the very high rate of output that can be obtained from this machine, it was decided to develop further equipment for use in large quantity production. This extra equipment gives automatic loading and unloading and automatic gauging of every workpiece. Gear blanks are placed in a hopper type loader and during production gear size tolerances are checked, 100 per cent, by the Michigan 3-way gear classifier. Any variation from the pre-set tolerances—caused by tool wear or other condition—is immediately picked up by the classifier and he proper signal relayed to a Michigan gear controller.

This controller performs several functions:—

(1) It automatically adjusts the hob centre distance to keep the gear sizes within the specified tolerances.
(2) It keeps a statistical record of production; that is, the total production, the number of rejects and other relevant facts.
(3) It shuts down production when the total predetermined gear production is reached, or should the helix angle not conform to specification.

Once the machine is started, all the operator has to do is to keep the automatic loader full of gear blanks. Should production be shut down automatically, as happens when the hob shifter reaches its limit, a light on the controller panel flashes, and the operator merely has to check the controller counters to determine where the difficulty lies. Gaston E. Marbaix Ltd., Devonshire House, Vicarage Crescent, London, S.W.11, are the sole British agents for these machines.

Axle case welder

An extremely interesting automatic flash butt welder developed by A.I. Electric Welding Machines Ltd., of Inverness and 68, Victoria St., London, S.W.1, is illustrated in Fig. 8. It is designed for simultaneous automatic welding of the two end flanges on automobile axle cases. The main axle casing is loaded on to the central fixture with spigot location, as shown in Fig. 9, and clamped by air-operated clamping units at the extreme ends of the casing. As the centre spigot is designed to take the reaction of the upset or forging pressures, the holding down clamp units exert only the pressure necessary for electrical contact; this reduces die wear to a minimum.

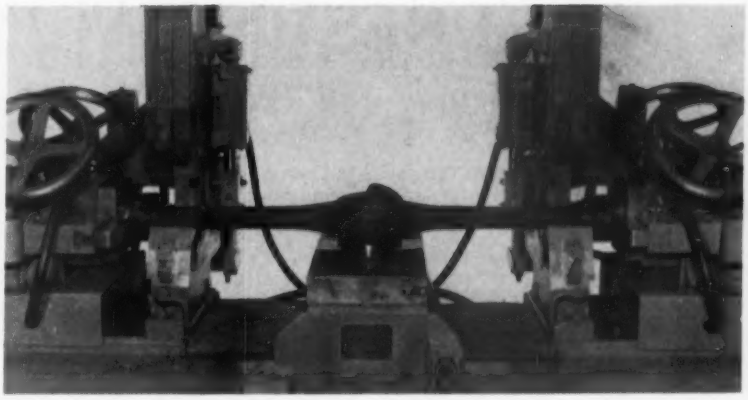


Fig. 9. The work-holding arrangements and welding heads on the machine shown in Fig. 8

The flanges are located on the electrode jig on each moving head. These heads are designed with quick acting, short stroke clamp action. Each flange clamp unit incorporates a novel design of universal adjustment for bringing the flange into perfect alignment with the casing before the welding cycle is initiated. The welding cycle is initiated through a single push button which controls both welding units. Cycle times range from 6 to 12 seconds, depending upon the size of the axle casing. At the end of the welding cycle, the clamps are released and the assembled axle is ejected from the dies by an air-operated lifting ejector system. The moving heads of the welding units are then re-set and the machine is ready for the next workpiece.

One of the special features of this machine is the wide range of axle sizes that can be accommodated. The two welding units are adjustable to take axle casings with overall dimensions ranging from a minimum of 32 in to a maximum of 62 in. Provision is also made for accepting axle casings with offset differentials down to a minimum of 11 in.

The two welding units incorporate the firm's patented air/oil intensifier power upset system, whereby an upset pressure of 8 tons is applied to the forging of the weld. A special feature of this power pack system is the provision of a control that is immediately adaptable to suit any particular size of axle casing and tube by a simple adjustment. Furthermore, this system of power development eliminates the necessity for oil pumps and accumulators. All that is required is a connection to an 80 lb/in^2 air supply main, since the upset or forging pressure is developed by intensification within a one-piece power unit.

A NEW CATERPILLAR TRACTOR

A 230-drawbar horse power crawler tractor with a turbo-charged engine has been added to the range of track vehicles manufactured by Caterpillar Tractor Co., Peoria, Illinois, U.S.A. The six-cylinder diesel engine has 6¼ in bore and 8 in stroke. It is governed to 1200 r.p.m. at full load and develops maximum torque at 800 r.p.m. Among other features, the engine design includes short valve push rods; stationary oil jets providing a continuous stream of oil to cool the pistons, the camshaft and followers; and steel-backed aluminium bearings, with the lower half of the centre main bearing arranged to take the camshaft thrust on a flange type bearing.

To minimize torsional vibration all accessories are driven from a gear at the rear of the crankshaft. A two-cylinder petrol engine is used for starting the diesel engine. There is a 6-volt electric starter for the petrol engine. The engine runs on fuel with a minimum cetane rating of 35; expensive, premium quality diesel fuel is not required. Economical operation is assured.

This new tractor may be fitted either with a special Caterpillar oil-type clutch or with a torque converter. The oil-type clutch has four metallic-faced plates with over-centre engagement. It is hydraulically boosted. Oil circulated under pressure, lubricates and cools the clutch, which is connected to the transmission by a double universal joint. When the oil-type clutch is fitted, there are six forward and six reverse speeds ranging from 1·6 to 6·8 m.p.h., and drawbar pounds-pull of 60,860 lb are possible with adequate weight and traction.

The torque converter is a three-stage, 5 : 1 torque multiplication unit that uses diesel fluid as hydraulic fluid. A 19 in single plate, dry-type flywheel clutch is used with the torque converter. Cooling for the torque converter fluid is effected by means of a heat exchanger mounted on the right-hand side of the engine. With the torque converter, there are three speeds forward and two in reverse.

SLUDGES IN ENGINE OILS

Comments on Causes and Prevention of the Formation of Sludge

SLUDGE in the lubricating systems of engines is frequently the cause of costly repairs. Fortunately, while the chemical investigations into sludge problems may be relatively complicated, the engineer can take simple steps to eliminate or considerably reduce sludge formation. Sludges found in automobile engines may be divided into two main categories; they are:

(a) Mixture of carbon, oil, partly oxidized oil, metallic particles or oxides resulting from engine wear, that is, iron, copper, aluminium and tin oxides, together with small percentages of road dust.
(b) Emulsions of these materials, together with varying percentages of water.

Sludges of type (a) are usually soft, black and often of a non-glutinous character, whereas those of type (b) are usually thick black pasty deposits and will readily choke up filters, oilways, etc., They cannot be removed satisfactorily without partly or wholly dismantling the engines.

How sludge is formed

In automobile engines, oil is forced at relatively rapid rates, by a pump that in many instances operates at high pressure, through the lubricating systems. The oil temperature may be as high as 200 deg F when entering the bearings. On leaving them in the form of a fine spray, it comes into intimate contact with heated air in the crankcase, in which, as a result of piston ring blow-by, there also are other gases such as carbon dioxide, and nitrogen, and fuel and water vapour. Under these conditions, the oil oxidizes at a rate that depends on its quality, its suitability for the unit and the amount of other impurities present. Some types of impurity accelerate the oxidation process.

Factors affecting composition

Sludges are, therefore, primarily the result of oil and fuel oxidation due to the effect of heat on oil in the presence of oxygen, part of the lubricant being burned to form carbon and semi-carbonized oil. They subsequently become mixed with other engine impurities, that is, road dust and metallic oxides, to form a sludge of type (a). The nature of such sludge varies according to:

(1) Type of oil—whether mineral or compounded
(2) Quality of the oil
(3) Mechanical condition of the engine
(4) The class of service—heavy or light duty
(5) Design of the engine, that is, whether the unit is of petrol, paraffin or diesel type
(6) Care exercised in maintenance and operation

Sludges of type (b) are usually formed when engines are operated under conditions that cause an accumulation of water in the crankcase. The water thus collected emulsifies with the solid impurities in the system and forms a thick, sticky sludge of dangerous character. This accumulation of water may be due to any one or more of the following causes:

(1) Condensation of steam entering the crankcase as a result of excessive piston ring leakage
(2) Water leakage from the cooling system—gaskets or pump glands
(3) Water contamination of fresh oil due to storage conditions or oil issue methods
(4) Insufficient crankcase ventilation
(5) Overcool running conditions due to extremely cold weather, inadequate protection from cold by the use of thermostats or radiator muffs, and intermittent service conditions preventing attainment of normal operating temperatures

As a result of sludge formation, the oil flow may be choked or restricted. This restriction may occur in oil filters, hollow crankshafts, oil gallery pipes, overhead rocker gears, valve chambers, timing gear cases, oil feed holes and passages, and in fact in most parts of engines. The danger is of seized bearings and excessive wear occurring due to faulty oil feed, or alternatively to the feeding of badly contaminated lubricant to heavily loaded bearings. This may make it necessary to replace important engine parts, and maintenance costs may be high.

How oils differ as regards sludging

Some oils, when used under adverse conditions, sludge more quickly than others. For example, pure mineral oils are more stable than compounded ones, especially in the presence of moisture; this explains why mineral oils are extensively used in petrol-driven commercial vehicles. Furthermore, some pure mineral oils are more stable than others according to their origin and method of manufacture. The oils most free from sludging tendencies are those made by the best and most proved solvent-refining method.

Counter measures

It is necessary to take the following factors into consideration when endeavouring to reduce sludging. The tendency to the formation of sludge emulsion is reduced when leakage past the pistons is minimized by maintaining rings, cylinder bores and pistons in the best possible condition. However, in certain circumstances, such oil deterioration may manifest itself, even when the mechanical condition of these components leaves nothing more to be desired.

Under normal summer conditions an excessive concentration of moisture does not generally occur in the crankcase. On the other hand, under winter operating conditions, particularly where the service is intermittent, water accumulation is common. It may be well, therefore, to give a warning of the importance of maintaining adequate crankcase ventilation. In a large number of engines, especially those used in motor transport services, a high percentage of the water present in the oil is due to the condensation of steam from combustion, as previously explained.

For this reason, vehicle operators should make sure that crankcase breathers are maintained in an effective condition, and that the engine is not overcooled: the correct working temperature of the water in the engine should be about 190 deg F. Because of this tendency towards water contamination, crankcases should be drained more frequently in winter than in summer. Other possible causes of contamination by water are: a faulty cylinder head gasket; in some designs, leakage from the water pump; faulty castings; and, perhaps, careless washing of the vehicle or unsatisfactory methods of oil storage and carelessness when filling the engine with oil.

Choice of oil

Since the rate of formation of sludge is directly dependent on the presence of oxidized oil and fuel, it is evident that the ability of the lubricant to resist oxidation must be high, and this object is attained by the employment of an efficient process of oil refining. Lubricants refined by the best solvent processes will remain, by virtue of their oxidation resistance properties, free from sludge over extended periods and give freedom from stuck rings and burned valves; crankcase dilution will also be minimized and operating costs reduced.

In addition, this type of lubricant helps to maintain the efficiency of the lubrication system, so the life of the engine is prolonged, reboring is only necessary after a much longer period of service and bearings are maintained in better condition. The use of anti-oxidant and detergent additives in high grade mineral oils results in increased stability against oxidation and much reduced sludging and engine wear. These additives also assist in reducing excessive corrosion and consequent wear when engines are operated under cold conditions resulting from intermittent usage. *Vacuum Oil Company Engineering Memorandum* 1024.

MEADOWS DIESEL ENGINES

Two New Horizontal Units Added to Range

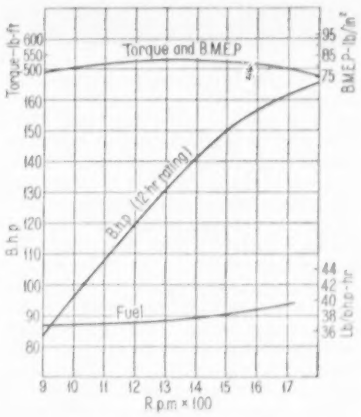
LONG known for their petrol engines, which were fitted to Fraser Nash, Lea-Francis, Invicta, Lagonda and other cars in the period between the two World Wars, Henry Meadows Ltd. also produced commercial and military vehicle engines of varying capacity and power output up to the 300 b.h.p., 12-cylinder, horizontally-opposed unit that powered the Covenanter tank. Soon after the end of the second war 4-cylinder and 6-cylinder diesel engines were introduced and since then Meadows engines have been mainly used in road transport, marine and stationary applications. Petrol engines are still produced in 4-cylinder and 6-cylinder units developing from 28 b.h.p. to 180 b.h.p. for those duties.

The range of vertical diesel engines currently in production includes 4-cylinder units of 5·43 litre and 6·9 litre capacity and 6-cylinder units of 10·35 litre and 15·9 litre in types specifically adapted for automotive, marine and industrial applications. For rail traction there are a 4-cylinder, 6·9 litre engine and 6-cylinder engines of 10·35 litre and 15·9 litre capacity. In all four types the largest 6-cylinder engine is available in a supercharged version equipped with a Brown-Boveri exhaust turbo-charger to raise the power output by approximately 50 per cent. To this total of 19 models is now added two horizontal engines to meet the present-day requirements of users aiming to secure maximum passenger or load-carrying capacity and unrestricted gangways in their vehicles, either for road or rail service.

Both horizontal engines are of similar cylinder dimensions to well-proved vertical units and many components are, of course, interchangeable between the two types. Thus the spares holdings by operators of vertical engines need not be complicated or extended by the introduction of the horizontal engines into their fleets. There has been little basic change in design, but the units were subjected to the maker's usual exhaustive tests over a period of 18 months for proving.

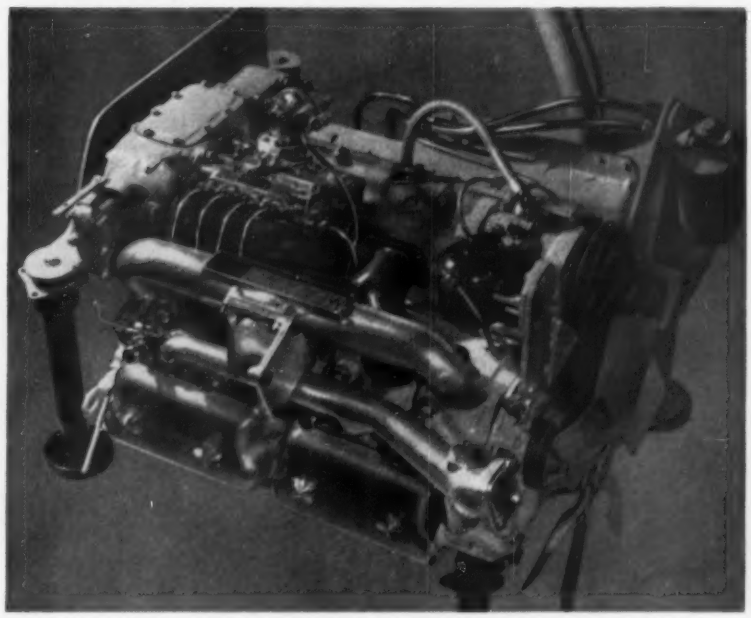
85 b.h.p. 4-cyl engine

The smaller of the two new engines, designated the 4 HDC 330, is specifically intended for installation in lightweight commercial vehicles or coaches. It represents a useful addition to the range of horizontal engines available to chassis builders, since units of this type are generally of larger size and higher power output. Like all Meadows diesel engines, the bore:stroke ratio is 1:1 and, while the specific fuel consumption is not higher than that of long-stroke engines, the relatively low piston speed results in a substantially lower rate of wear. Bore and stroke are each 120 mm, giving a swept capacity of 5·43 litre or 331 in³. Compression ratio is 16:1 and the piston speed is 1,735 ft/min at the rated maximum speed of 2,200 r.p.m. Power output at that speed is 85 b.h.p. and the maximum torque of 230 lb-ft is developed at 1,350 r.p.m. Approximate overall dimensions are, length 39¼ in, width 50 in, and height 24 in, and the weight, including the flywheel, is 1,100 lb. The standard direction of rotation is anti-clockwise, viewed from the flywheel end.



Performance curves, 4-cyl unit

Five main bearings in the cast iron engine block carry the four-throw crankshaft, which is hardened to V.P.N. 620. They are 3·353 in diameter and of the thin-shell, steel-backed, precision type, lined with copper-lead and are lead-indium flashed. Cylinder liners of centrifugally cast alloy iron are of the wet type and two detachable heads, each covering two cylinders, are fitted. Stamped steel, H-section connecting rods have their big-ends proportioned so that they can be withdrawn with the piston through the liner bore. Big-end bearings of 3·00 in diameter are of the same type as the main bearings, while the small-end bearings are copper-lead lined steel bushes. The die-cast aluminium alloy pistons are flat-crowned and formed with a slightly offset toroidal combustion space. Three compression rings are fitted and the two oil control rings are arranged one above the 1¼ in diameter, fully-floating gudgeon-pin and one in the skirt. The uppermost compression ring is chromium plated to reduce liner wear.



Overhead view of 85 h.p. 4-cyl unit. The mounting arrangement is non-standard for a specific application

Cylinder heads



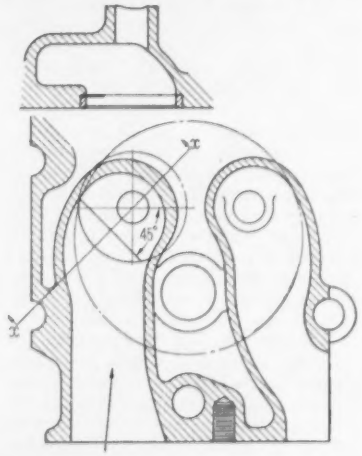
Front end view of 4 HDC 330 engine showing drives for water pump and fan, dynamo, and exhauster

carry one inlet and one exhaust valve per cylinder and renewable valve seat inserts of a centrifugally cast, high-chromium iron are provided for both valves. The inlet valve is of normal symmetrical shape and is not of the usual shrouded type. Instead, the induction swirl is controlled by the Meadows patented masking device, as shown in the detail drawing. This comprises a sheet metal chordal segment which is secured, with its chordal edge at an appropriate angle, in the port throat above the inserted valve seat. The exhaust valve is Stellite faced. Valves are actuated by bucket-type tappets and short push rods and rocker gear from a high-level camshaft on the underside of the cylinders. The camshaft runs in five white-metalled bearings of 2·25 in diameter.

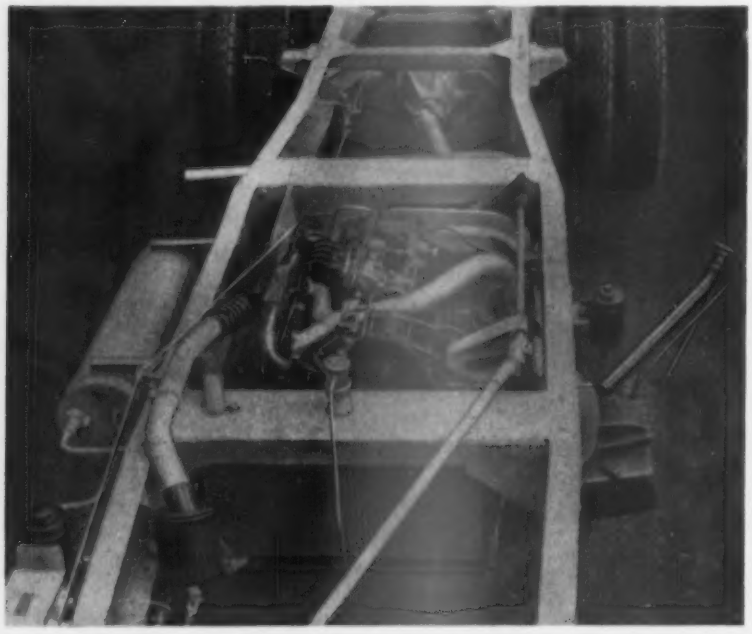
It may be recalled that all Meadows four-cylinder engines of the vertical type are equipped with a harmonic balancing system. It comprises a pair of counter-rotating shafts with balance weights, located below the crankshaft and driven from it by helical gears at twice engine speed, to damp out the secondary reciprocating forces. It has been found that with the engine arranged horizontally, these forces, acting in a horizontal instead of a vertical plane, can be satisfactorily absorbed by the engine mountings. Accordingly, the balancing shafts are deemed unnecessary for the horizontal engine and are not fitted.

Timing is by helical gears from the flywheel end of the crankshaft. A C.A.V. or a Simms fuel injection pump unit is controlled by a Meadows centrifugal-type governor and incorporated in the drive is the Meadows patented automatic advance mechanism. In this a roller moves, under the influence of centrifugal force, between inclined cam faces on driving and driven elements to advance the commencement of injection as the engine speed is increased. Thus the optimum point of fuel injection is maintained throughout the engine speed range. The injectors are of the long-stem type with multi-hole nozzles.

A wet-sump lubrication system is employed. The sump has an oil capacity of approximately 2½ gal and a Hobourn-Eaton pump circulates the oil at a pressure of 50 lb/in² to main and big-end bearings, camshaft bearings, valve rockers, and gear drives. All oil circulated is passed through a filter of the renewable element type.



Meadows patented port-masking arrangement for promoting induction swirl



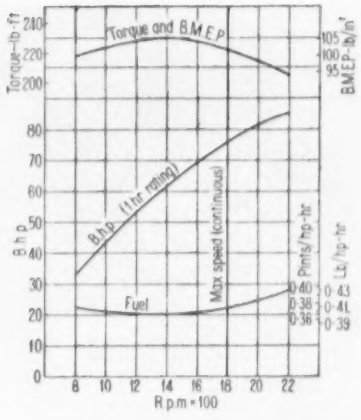
4-cyl engine installed in a Rowe coach chassis

Twin rubber belts from the crankshaft drive the centrifugal water-circulating pump at the front end of the engine and water temperature is controlled by the usual thermostatic valve. An 18 in diameter six-bladed fan is mounted on the fan spindle. The drive is triangulated by the 24-volt dynamo. Both dynamo and starter units are mounted on the underside of the engine block. Decompression gear, operating on the valve rockers to hold the exhaust valves off their seats, is fitted to facilitate starting. As required, either a vane-type exhauster or a piston-type compressor for the vehicle braking system can be mounted on the upper side of the block and driven by belt from a crankshaft pulley.

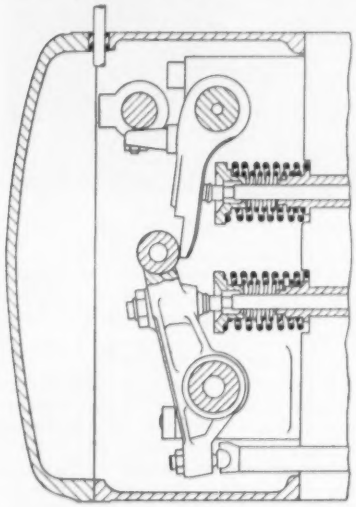
165 b.h.p. 6-cyl engine

This unit, type 6 HDT 970, is of particularly robust construction in order to ensure the reliability expected in railcar operation. The layout of the auxiliaries differs from that usually adopted for road vehicle engines in that all, including the fuel injection pump unit, are located to one side, the crankcase side, to confer the maximum

accessibility when the engine is installed. To facilitate servicing, the high-pressure fuel pipes are joined at a special "bulkhead" fitting on the upper side of the engine block. On a 12-hr traction rating the output is 165 b.h.p. at 1,800 r.p.m., on a b.m.e.p. of 83 lb/in², and specific fuel consumption at that rating is 0·40 lb/b.h.p.-hr. Bore and stroke are 150 mm and the swept volume 15·9 litre or 970 in³. Piston speed is 1,770 ft/min at 1,800 r.p.m. and the engine operates on a compression ratio of 16:1. In view of the construction and since many of the



Performance curves, 6-cyl engine



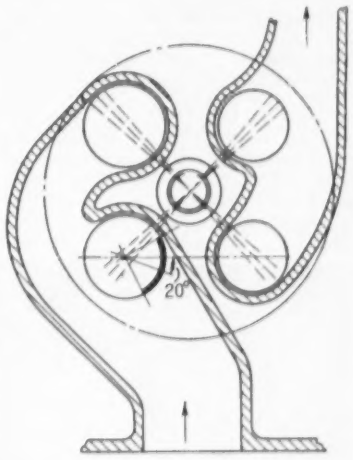
Overhead valve rocker gear on 6-cyl engine

component items are of cast iron instead of light alloy, the specific weight of the engine is considerably higher than that of the unit previously described. Total weight, including the flywheel, is about 3,800 lb. Overall dimensions are approximately 64 in long, 68¼ in wide and 31 in high.

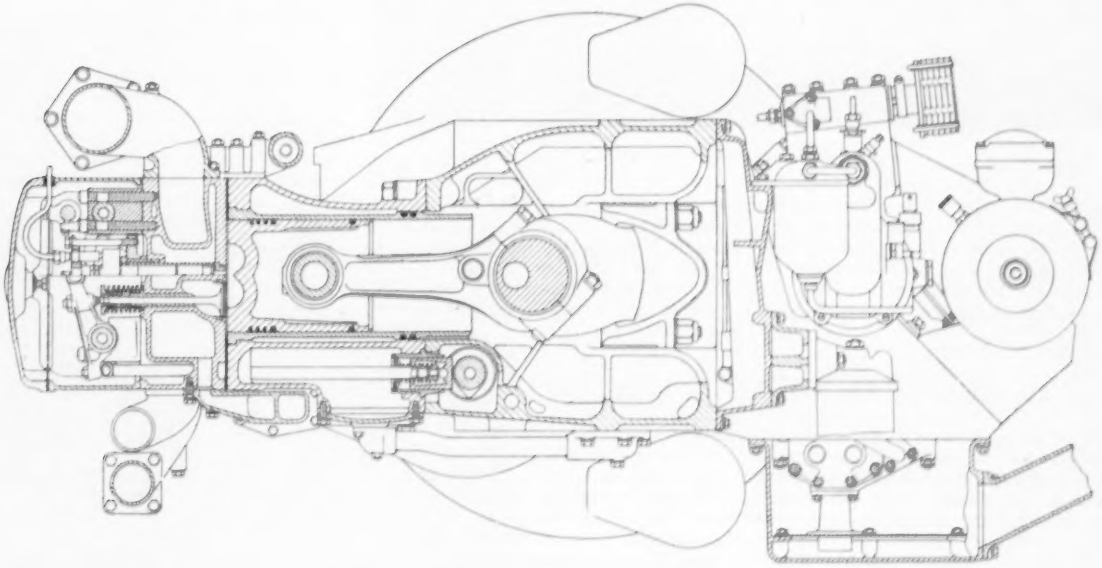
Instead of an engine block, this unit has a separate crankcase and two blocks of three cylinders, which are fitted with wet-type liners. Cylinder heads are also cast in blocks of three and in this instance are provided with four valves per cylinder. Pairs of valves are operated by a single push rod and relay-type overhead rocker gear. Renewable seatings are fitted for all valves, but of the two inlet valves only one is shrouded for swirl control. The position of this valve and the pattern of the fuel sprays is shown in a detail sketch.

The crankshaft, nitrided to V.P.N. 850, has main journals 4·25 in diameter and crank pins of 4·00 in diameter. Steel connecting rods of H-section have angled big ends to permit withdrawal through the liner bore and are drilled for positive oil feed to the small end. Both the seven main journal bearings and the big-end bearings are of the thin-shell, steel-backed, copper-lead type. Small-end bearings are pressed-in bushes, machined to size after insertion. Three compression rings and two oil control rings are fitted to the forged aluminium alloy piston. It has a co-axial toroidal combustion space and, as before, a fully-floating gudgeon pin.

As the seven-bearing camshaft is located below the crankshaft, in what would normally be termed a "low-level" position, the push rods are relatively long. Accordingly, to reduce the inertia effects on the rocker gear



Disposition of shrouded inlet valve and fuel spray pattern in four-valve head

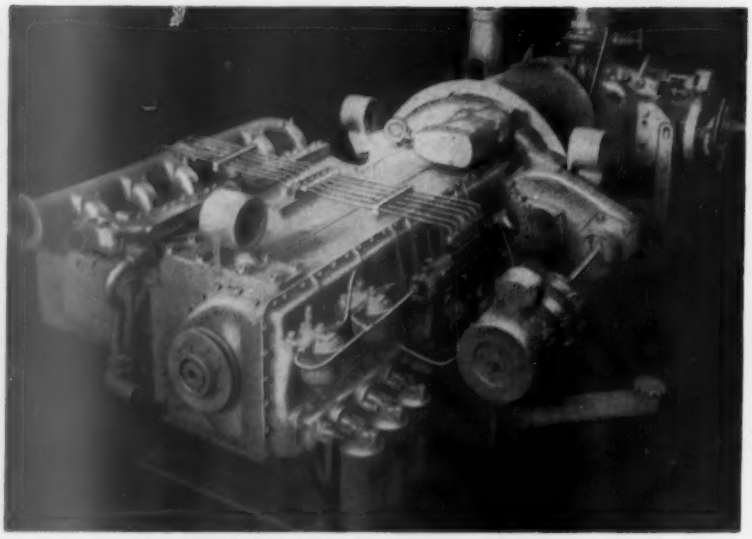


Transverse sectional arrangement of 6 HDT 970 engine

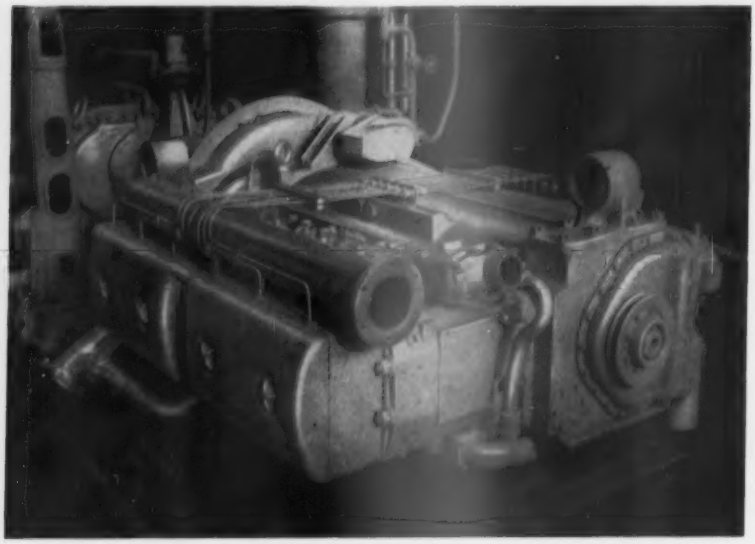
and valves, each rod is loaded into its bucket tappet by a compression spring. All auxiliaries are driven by means of helical gears from the flywheel end of the crankshaft, since in that position gear-drive noise created by torsional oscillation of the shaft is minimized. It is regarded as specially important in an engine of this size that the water pump be gear driven to obtain the maximum reliability. Water circulation is thus rendered independent of the adjustments necessary with the more usual belt drive.

Fuel injection equipment is of C.A.V. manufacture. The fuel is passed through a triple-bowl filter of the paper element type and the pump unit, complete with a C.A.V. centrifugal governor, delivers it to long-stem, four-hole injectors. The Meadows automatic advance is embodied in the drive to the pump.

A gear-type oil pump driven from the main timing gear train delivers the main feed from the pannier sump below the wet sump to the crankshaft bearings. An auxiliary pump feeds oil to the camshaft, valve rockers and the gear drives. Oil is delivered through twin full-flow filters conveniently mounted on the crankcase end cover adjacent to the fuel filters.



On the 6-cyl engine, auxiliaries are mounted on the crankcase cover



6 HDT 970 engine on the test bed

Electric starting equipment is fitted as standard and includes two 24-volt starter motors. The dynamo is gear driven from the timing train at either 1·645 or 2·22 times engine speed. Decompression gear is provided. On the standard engine a three-point suspension is arranged, but alternative methods of mounting can be supplied to meet specific installation requirements.

Supercharged unit

An exhaust gas turbo-charged version of the six-cylinder horizontal engine is available. The Brown-Boveri turbo-charger unit is mounted at the forward end of the engine, with its axis slightly above the plane containing the axes of the cylinder, and is fed by a separate cast iron exhaust manifold from each of the cylinder head blocks. It is water-cooled from the engine system. The air intake can be through a directly mounted filter-silencer, or a flanged connection can be provided for a ducted supply from a remotely sited filtering arrangement.

Operating with a compression ratio of 15:1, the supercharged engine develops 240 b.h.p. at 1,800 r.p.m., on a 12 hr continuous rating. The maximum b.m.e.p. is 120 lb/in² and the specific fuel consumption is reduced to 0·358 lb/b.h.p.-hr. The addition of the turbo-charger increases the overall dimensions of the unit to length 77½ in and width 73 in. Height is unaffected at 31 in. Although the weight, including the flywheel, is increased from 3,800 lb. to 4,100 lb the specific weight is reduced from approximately 23 lb/b.h.p. to 17 lb/b.h.p.

FLAME HARDENING CENTRIFUGALLY CAST IRON LINERS

CENTRIFUGALLY cast iron has advantages for cylinder liners in its graphite content, oil-retaining porosity, and simple, economical production. Its carbon content generally lies between 3·2 and 3·5 per cent, of which 0·5 to 0·7 per cent exists in combined form as pearlite.

Liners may be hardened for increased wear resistance. Hardening processes include through hardening, flame hardening, induction hardening, nitriding, and hard chromium plating. Advantages and disadvantages of these processes are discussed, and it is concluded that flame hardening has advantages in production economy, low distortion, and ductility of the unhardened part of the liner. Sensitivity to wall thickness, however, generally precludes flame hardening of thin-walled "dry" liners.

In *M.T.Z.*, September, 1954, H. Steiger describes in detail a flame-hardening machine for cylinder liners. Accurate temperature control and measurement and control of the feed, are important. Burner design affects the depth of hardness and various types are illustrated.

HARDENABILITY

A Simple Method of Determining Transverse Hardness Curves

H. M. Walter, Dipl. Ing.

NORMALLY the Jominy "end quench test" is used to determine the hardenability of steels. Although this is a very valuable test, the results obtained only allow theoretical calculation of the hardness transverse curve for the actual piece of material from which the test piece has been taken. These curves can vary considerably from cast to cast; even on one and the same test piece considerable differences are possible. This is shown definitely by the results obtained on a piece of 3 in diameter and described in the *Symposium on the Hardenability of Steels*, Special Report No. 36 of the Iron and Steel Institute, pages 199-216. This statement is not intended to question the value of the Jominy test itself, since results do indicate the hardness values obtainable by heat treatment, especially when applied to the ordinary types of construction steels. However, on shallow hardening steels and on high alloyed steels with a cross section exceeding 4 in-6 in, the results are not too reliable, as explained in the above-mentioned Report.

On tool steels a certain depth of the hardness may be essential and a complete hardening throughout the workpiece may not only be unnecessary but in certain circumstances even not desirable. If a steel is to be used for this purpose, a knowledge of the hardness transverse curve is of great importance since, in addition to indicating whether the material has suitable hardening characteristics for the intended purpose, it will also give information regarding probable tool life. With cold rolls, for example, it is important to know whether the depth of the hardened layer might be expected to be deep enough to give a reasonable life and yet not crack under the rolling load. Furthermore, it is important to know, and as far as possible control, the ratio with which the hardness drops to the core. More or less the same ideas apply to the manufacture of dies, etc. On the other hand, shafts on motors, etc., may have to be hardened through in large sections and it may be seen from the above-cited Report, that the hardenability above certain cross sections cannot always be reliably determined by the Jominy test.



Fig. 1. Components for the hardenability test

On small diameters there will be no difficulty in determining a hardness transverse curve as such material can easily be hardened, broken, ground and tested. On large sections, however, this method becomes very expensive. In order to obtain the proper hardness transverse curve of a round bar, for instance, a test piece must be prepared with a length of three times the diameter, to avoid any influence of the heat treatment from the end pieces. When steel for cold rolls is to be tested, the middle part of the test piece has to be divided by cutting wheels into a section of suitable length for testing, which procedure not only takes a very long time, but there is also the danger of re-tempering during cutting. This, of course, would invalidate the results. As only the middle part of each long test piece can be taken into consideration, this process involves a big loss of material.

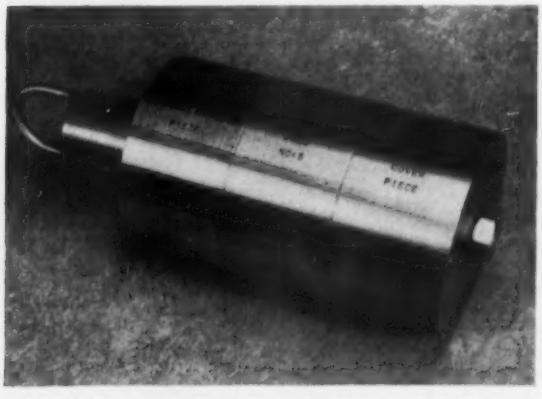


Fig. 2. Test piece assembled for heat treatment

For certain research work, this nuisance had to be avoided and after careful consideration, the following test procedure was evolved. The main point was to obtain reliable values for the hardening transverse curve, but it was also important to keep the costs to a minimum for both material and machining, and to reduce the time spent to prepare for testing.

For testing, only a round disc is needed. It is cut and turned to size, with a drilled centre hole for fixing a bolt. This can be done in the annealed condition. For good results, the thickness of this disc should not be less than about half the diameter of the test piece. If shallow hardening steels are concerned, discs under this size may show a slightly deeper penetration of the hardness than may take place in a solid workpiece.

Each side of the test piece is covered by a piece of mild steel held in position by means of a bolt. Great care has to be taken that the faces are properly ground and fit tightly on to each other. The so-called "cover-pieces" must have a length of at least $1\frac{1}{2}$ times the diameter. Fig. 1 shows the various parts before assembly and Fig. 2 the assembly ready for heat treatment.

If there are different types of steels to be tested at the same temperature, it is possible to put all the test pieces in the middle and to place the cover-pieces only on both ends of each such "combined" roll. Should it be necessary to anneal or normalize the material prior to heat treatment, this procedure should be carried out before the final grinding of the faces. Thereafter the pieces can be assembled and treated. This is only a precaution to ensure that, after the annealing or normalizing, the faces have the required tight fit.

Naturally, the cover-pieces can be used for the same dimension for a number of times as long as the diameter corresponds with the test pieces; later, they can be turned down for use with smaller test pieces. The faces must be ground each time they are used again.

After heat treatment is completed, the cover-pieces are removed and the

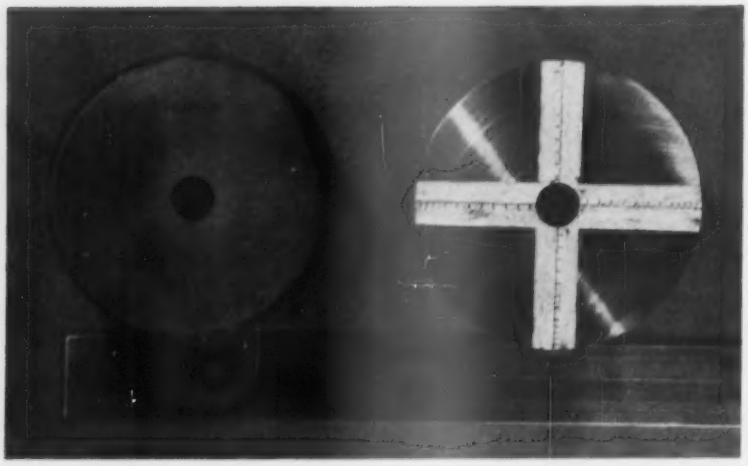


Fig. 3. At the left a test piece immediately after quenching, at the right a test piece prepared for hardness readings

face of the test piece is ground, with water as a coolant. This grinding operation is purely a precautionary measure designed to correct any distortion and to eliminate the danger that readings are taken from portions that may be either carburized or decarburized. Normally, it is not necessary to remove more than 0·02 in. The test piece, before grinding, is shown at the left in Fig. 3 and a test piece ready for hardness readings at the right.

Hardness readings are taken at various points across the ground face. It is recommended that the average be taken of readings across two different diameters. The distance from the surface of each spot should be very accurately marked. This is particularly important in testing shallow hardening steels, for which type of steel it is also essential to have the reading points as close together as practicable without one reading influencing the next. The final reading should be taken at least ¼ in from the bolt hole.

The results obtained with this method are quite as reliable as those where the test piece consists of one relatively long solid bar. This has been proved by etching a longitudinal section from a shallow hardening steel to show that the end faces of the test piece, where the cover-pieces make contact, harden in exactly the same way as the middle portion. This method also gives consistent results. For example, two 4 in diameter test pieces of the same steel were treated at the same temperature, and the average values of four different radii are remarkably consistent. They are given in Table 1.

Table 2 gives the values obtained by this method in comparison with those taken on a solid test piece with a length three times the diameter. After heat treatment, the solid test piece was divided by means of a cutting wheel. It will be seen that the values correspond remarkably well. If it is not necessary to obtain values in the tepid condition also, the hardened pieces, after being tested in the "as quenched" condition, can be reassembled and tempered at any desired temperature. This provides a simple and cheap method of producing a tempering curve with a reasonable degree of accuracy and also for finding the time necessary to treat the whole of the cross section. Finally, if the test pieces are sufficiently long, tensile test or Izod test pieces can be machined from them without too much waste of material.

TABLE I. Transverse hardness values of two steels of the same composition

Distance from surface, mm.	Rockwell C Hardness	
	Specimen A	Specimen B
2	58	58
4	53	52
6	46	46
8	46	45·5
10	46·5	45·5
16	44	44
22	41·5	42
28	41·5	41·5
34	41·5	42
40	42	41·5

TABLE II. Rockwell C transverse hardness values by (a) the method described and (b) from a conventional hardenability test

Material	Testing method	Distance from surface, mm.						
		2	4	6	8	18	26	34
En 31	a	46	45	44	43	42·5	42	41·5
	b	46	45	44·5	43	42	42·5	41
En 24	a	49·5	49·5	49·5	49	49·5	50·5	48
	b	49	49·5	49·5	49	49	50·5	48·5
En 111	a	39	37·5	37	35	32	33	33
	b	39·5	37	37	35	32	32·5	33

HAND PALLET TRUCKS

A NEW model HP 50 hand pallet truck has been developed by Lansing Bagnall Ltd., Basingstoke, Hampshire, to give the best service under conditions where power trucks cannot be used. The all-steel welded frame of this new truck is built of strong box sections which result in a capacity of 4,500 lb with a service weight of only 3 cwt. This should be compared with the Lansing Bagnall power pallet truck which weighs 1,600 lb. This very large capacity will normally not be fully utilized, as it would, of course, require the services of perhaps two operators to move a full load. In some departments, such as in maintenance and millwright shops, it is, however, extremely useful to have a truck to hand which can carry such loads.

The new truck can be supplied with standard fork lengths from 36 to 72 in, and with overall fork widths of 22 or 27 in. The hydraulic pump for raising the load off the ground is operated by the handle, and the connecting leverage system is arranged to give the maximum effect towards the top position of the handle, so that heavy loads can be lifted easily even in the most cramped surroundings.

Full lift is 6 in instead of the usual 4½ in for normal pallet trucks. This high lift ensures ample ground clearance for extra wide pallets which are apt to sag. It also provides adequate ground clearance when negotiating ramps and other sloping surfaces. The jack is specially designed to raise the load truly vertically. It is located inside the tank containing the hydraulic oil, so that in the event of any small leakage, the oil goes straight back into the tank. The bearings of the steering gear are also continually lubricated by the hydraulic fluid, since they are housed inside the tank. The handle can be latched in the vertical position for push and pull manœuvring in confined spaces.

Chamfered fork tips reduce the possibility of damaging the pallet or stillage. In addition, the retracting mechanism is completely protected from damage by the box-section forks.

TRANSFER MACHINES

Notes on Recent American Developments and Practice

ALTHOUGH in-line transfer machines for the automobile industry were originally developed in this country by James Archdale Ltd., it is only in the last decade that they have come to be regarded as essential equipment for any automobile factory engaged in large quantity production. For readily understandable reasons during this decade, there has been much more intensive development and wider use of such machines in the United States of America than in this country. While the automobile industry in this country can scarcely expect to compete with the American industry in terms of output—and the larger the output, the greater the advantages to be gained from increasing the automatic factor in production processes—several British factories have sufficiently large outputs to warrant a wider use of what is now generally known as "automation."

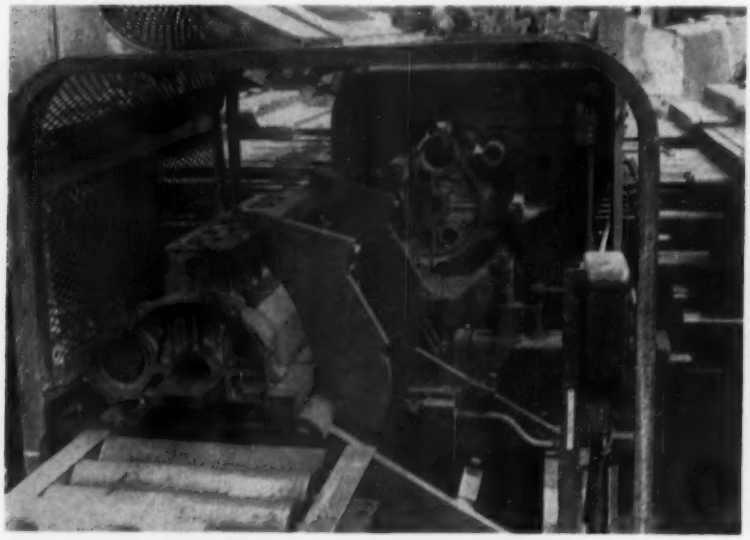
Some conception of the developments that have taken place may be gained from the Transfer-matic machine developed by The Cross Company of Detroit for machining cylinder blocks. This machine is 356 ft long, carries out 555 machining operations and 133 inspection operations. It handles the work in seven positions and, under the control of one operator, produces 100 blocks an hour. With a machine of this character, reliability becomes a much more important matter than it is in the case of single station machines. Where production is carried out on a number of single machines, down time at one machine does not seriously affect the production at another operation. When, however, a whole sequence of operations is combined in an in-line transfer machine, any delay at one station automatically stops production at all other stations. Therefore, dependability becomes a matter of primary importance.

Briefly, the usual functions of an in-line transfer machine are:—

(1) Transfer workpiece to the first station and from station to station.
(2) Locate and clamp the work at each station.
(3) Rapid approach of the tools to the work.
(4) Feed the tools through the cutting cycle.
(5) Retract the tools clear of the work and the guide bushes.
(6) Unclamp the workpieces at the various stations ready for further transfer.

This calls for the closest co-operation between machine tool, hydraulic and electrical engineers.

In basic design, the various heads on a multi-station transfer machine will follow the best modern practice for single station machines for similar operations, but because of the need for greater reliability, they are generally built up from somewhat more robust components than would be used for a single station machine. Certain other factors, such as chip removal and coolant supply, call for much more detailed study on an in-line transfer machine than is necessary for a single station machine.



On this 9-station transfer machine at the Dagenham works of Ford Motor Co. Ltd., the cylinder block is loaded direct on to the transfer bar. The loading station incorporates an automatic turn-over device

The spindle heads must be designed with substantial gear trains, bearings and spindles mounted in a housing that will permit continuous transmission of full horse-power with a minimum of deflection and vibration at the cutting tool. In some of the earlier machines there was an occasional tendency to use relatively small diameter spindles in order to mount all the tools for a certain operation at one station. Experience soon showed that this was not sound policy. The spindles had a tendency to whip, and as a consequence the accuracy of the machine was soon impaired and the tool life was short.

To-day the general practice is to regard 2½ in as the minimum permissible centre distance for spindles to carry drills, reamers and taps up to ¾ in diameter. The spindles are also kept as short and rigid as practicable. Where a long spindle must be used, it is the practice to provide an outboard support either on the head or on the work-holding fixture, whichever is the more convenient.

Automatic lubrication must be provided for the spindle heads, and oil seals to prohibit the entry of dust and coolant and prevent oil leaks must be fitted where necessary. Because of the continuous employment to which this type of equipment is subject, it is general practice to provide an oil filter to keep the oil free from contaminants. It is also highly desirable to incorporate some form of warning signal that will operate in case of lubricant failure.

In the earlier machines the driving motor was connected directly to the drive gear by a flexible coupling supposed to accommodate the permissible variations in motor shaft heights. This arrangement did not prove to be altogether satisfactory, and it is now the general practice to transmit the drive from the motor to the driving gear by vee belts. The motor mounting must be adjustable to allow different pulley combinations to be used and to allow the correct belt tension to be maintained.

Practical experience has shown that while cast iron ways may be used on vertical units, they are not suitable for horizontal or angular units, since they will pick up chips and score both the way and the slide. Steel ways hardened to at least 60 Rockwell C are recommended. Tests have been made recently with slides or ways of plastics material; they have met with varying degrees of success. However, no matter what material is used, wipers should be fitted at each end of the slide to remove chips and other foreign matter. Furthermore, any combination of

metals, or of metal and plastics, must be well lubricated. An automatic centralized system is advisable. It should be designed to meter the desired quantity of lubricant at each outlet at regular periods. It should also incorporate provision for shutting the machine down when the lubricant in the reservoir falls below a safe level.

The type of drive for feed and rapid traverse is largely governed by the type of operation. If it is essential to maintain a definite chip load per tooth or to maintain a very accurate time cycle, the general opinion is that an electrically-controlled mechanical unit should be employed. Where, however, the operation is very quick, six cycles or more per minute, it is usually better practice to use hydraulics. Hydraulic systems are more flexible and, therefore, more easy to apply and more economical. Each system must be designed for automatic control which can be initiated and interlocked with any form of automatic transfer that may be applied.

Adjustable tool holders to provide for end wear on the tools are essential. It is also advisable to have spare sets of tools mounted ready in holders and set to special gauges to give precise duplication of the distance of the cutting edge to the end of the spindle. The extra expense involved is much more than offset by the savings effected through reduced time for tool replacement.

On a single-station machine the tools are under constant observation and there is no excuse for running a tool when its efficiency is impaired. With multi-station transfer machines, however, the operator has little or no opportunity of keeping a check on tool behaviour. Because of this some production engineers think it advisable to legislate for tool change after a specified number of operations have been performed. The Cross Toolometer has been developed for use in conjunction with such schedules. It is a mechanical memory device which counts the number of operations performed. After a tool completes the scheduled number of operations, the Toolometer automatically shuts the machine down ready for the tool change.

With work such as cylinder blocks and other parts having one or more machined faces and two reamed holes to take locating dowels, the general practice is to load the work direct on to the transfer bar. For certain classes of work, it is necessary to mount the workpiece on a plate or fixture before it is loaded into the transfer machine. The plate or fixture will, of course, incorporate two reamed holes to take the locating dowels at each station. In both types, the work or the plate is clamped against hardened rails or pads at each working station. Both the dowel pin operation and clamping are effected by means of hydraulic cylinders or hydraulic motors geared to clamp screws. Great care must be taken to determine the force exerted by the clamping action, since it must be sufficient to hold the work rigid against the action of the cutting tools but at the same time not sufficient to distort the work.



The control panel and loading station of a 21-station for gearbox casings at Vauxhall Motors Ltd. The workpiece is mounted on a carrier plate before being loaded into the machine

Normalized cast iron is recommended for fixture frames as the best material for retaining shape and absorbing vibration set up by the cutting action. The fixtures must be so designed that the chips produced by the tools fall freely away from the machine. Tool guide bushes should be mounted in liner bushes so that accuracy is not destroyed when it is necessary to replace them. The bushes for a number of related holes in one face, such as the joint face of a cylinder head, should be mounted in a plate that is separate from the fixture frame.

In effect, a transfer machine comprises a number of special machine tools, which are connected by conveyors and interlocked electrically. The electrical and hydraulic circuits are important factors influencing the efficient functioning of the machine. In recent years considerable advances have been made in designing and installing systems that will have greater reliability with greater simplicity of maintenance.

The electrical control circuit must be such as to prevent the starting of any one machine function before the previous one is completed. It should also incorporate means for readily locating the cause if there is a failure in the circuit. A typical transfer machine will incorporate four circuits. The first will control a solenoid-operated hydraulic valve for the transfer cylinder. At the end of the transfer motion, the second circuit is energized to control a hydraulic valve directing oil to each of the work-positioning and clamping cylinders. When the workpieces are correctly positioned and clamped, a limit switch at each station is closed. The last station at which clamping is effected closes the last limit switch to complete the circuit controlling the feed of each of the machine tool units.

Each unit as it reaches the end of the in-feed stroke closes a switch; at the end of the return stroke it closes a second switch that completes the circuit operating the clamping cylinder valve; this releases the clamps from the workpiece at the particular station. As each fixture is unclamped, it closes a switch until the last one to be unclamped completes the fourth circuit to an indicator light that shows the machine cycle has been completed.

Limit switches are, of course, essentials on any machine that has to carry out a number of co-ordinated movements. For example, on the Transfer-matic machine mentioned earlier in these notes there are no less than 505. Frequently, it is difficult to mount the switches in positions where they can do their work and still be amply protected from coolant and swarf and be accessible for servicing. To reduce the number of switches required, it is now becoming fairly common practice to tie together similar mechanical actions on a machine in such a manner that one limit switch can indicate the completion of a group of mechanical movements. For example, on a 25-station machine there will be 50 locating dowels that must be advanced to locate the work and retracted to allow each workpiece to be transferred to the next station. If these pins are interlocked mechanically, only one power source and two limit switches will be required; without mechanical interlocking at least 50 limit switches would be required.

The complete electrical system must be designed to meet these requirements:—

(a) Safety for the operator and maintenance men.
(b) Failure of an electrical component must not damage the machine or the work.
(c) Long component life.
(d) Ease of maintenance.
(e) Simplicity and flexibility of control for the operator.

To ensure that the machine is safe operationally, there must be no danger of exposure to high voltage and no possibility of unintentional movement of any part of the machine. Good wiring and careful siting of piping and terminal boxes to prevent any danger of damage are primary necessities for safety from electric shock. It is important to have a circuit breaker (to interrupt short circuits) through which all the machine is fed; in the case of multiple machines it is often advantageous to arrange that separate well-defined groups of machines are fed through separate circuit breakers. The breaker must have its handle interlocked with control cabinet door so that the door cannot be opened until the power is switched off. This is particularly important when the cabinet is on the shop floor or attached to the machine and all the control is in one cabinet.

If an electrical component fails it must stop the movement depending upon it and not cause a false operation of the machine. As machines become more complex this takes on added importance. One way to ensure this is to design the control circuits in such a manner that, as far as possible, each motion is the result of energizing a relay coil, solenoid valve or starter. With this arrangement, if a wiring or coil failure occurs, all that happens is that part of the machine will not move. Mechanically latched relays are also used for this purpose. They may be used to energize a hydraulic solenoid valve to maintain clamping fixture, even though part of the control may be de-energized owing to a failure. Latched relays can also be used to determine the direction of travel of a shuttle or head so that when the cycle is resumed after a loss of voltage due to failure, the relay "remembers" in which direction the shuttle or head should be moved.

Electrical component life is, of course, important on any type of machine, but it has added importance on multi-station transfer machines for two reasons. Firstly, the fault is usually more difficult to locate; secondly, if one station is idle through electrical failure, the whole machine is stopped. As a result of experience with the earlier transfer machines, the manufacturers of electrical controls have greatly improved the available equipment and eliminated many control troubles that were previously experienced.

The tendency to link more and more machines together has, of course, led to a great increase in the number of limit switches, relays and solenoid valves required for controlling and synchronizing the machine functions. As these components are mechanical in character, they are subject to failures that may lead to excessive maintenance charges and loss of production. Investigations are now being carried out with a view to replacing these mechanical devices by electronic eyes, vacuum or thyratron valves, transitors and other electronic devices.

As a direct result of the developments in multi-station transfer machines, there have been considerable improvements in hydraulic systems and circuits. In the earlier machines it was the general practice to mount the pump, operating valves and oil reservoir inside the machine to keep them safe from inadvertent damage. This location made servicing difficult because of the inaccessibility of the units and frequently affected the accuracy of the machine through heating of the hydraulic oil.

To-day, the commonly accepted practice is to mount the pump, driven by its own motor, and actuating valves on an individual reservoir separate from the machine. On a multi-station machine the individual hydraulic units are placed in line along one side of the machine or placed on a catwalk above the machine in close proximity to the electrical panels.

Gasket mounted control valves and cartridge-type pumps are used almost universally. A gasket-mounted valve can be replaced in a matter of minutes without any disturbance of the piping. The incorporation of gauge ports throughout the circuit allows faults to be traced with a minimum of delay. Circuit design has been markedly affected by the development of multi-station machines. For example, the necessity for complete electrical interlocking to ensure correct sequencing of related movements has virtually eliminated the pilot-operated circuit. Electrically controlled directional valves to isolate the control of each motion are now used instead of sequence valves.

The solenoids used for operating the hydraulic valves are probably the items that call for most frequent maintenance. Moving the valves away from the machine has greatly simplified maintenance on the solenoids. It is, however, still necessary in some applications to mount the valve near the machine. In such cases, the Cross Company have found it advantageous to separate the solenoids from the valve they operate. Through this arrangement the solenoids can be serviced separately from the hydraulic valve, or the valve can be removed and replaced without there being need for an electrician to disconnect the solenoid. These solenoids are mounted in an oil-tight compartment. The present practice is to mount the solenoid on the cover, rather than in



An indexing station on a transfer machine. The casting is turned through 90 deg on the vertical axis



At this station long drills are necessary. The drill guide bush plate advances and retracts with the head

the compartment, so that it is definitely necessary to have the cover in place before the solenoid can be operated.

In the earlier machines, the hydraulic cylinders often called for excessive maintenance owing to mechanical failures and seal leaks. Modern units, with self-regulating taper-proof seals, have greatly reduced maintenance costs. Nevertheless, there is still need for maintenance, and accessibility is important. But hydraulic cylinders must be attached to and operate some machine part. When a direct attachment to the mechanism to be moved results in poor maintenance characteristics, certain machine tool makers incorporate some form of remote connection that will give good accessibility.

The question of eliminating leaks in the hydraulic circuit is one that has exercised all the makers of multi-station transfer machines. To reduce the incidence of leaks, one organization eliminates as far as possible all threaded pipe fittings. Manifolds which can be "O" ring sealed are used instead. Experimental work, which appears to offer good prospects of success, is also being carried out on pipe threads with dissimilar male and female tapers.

Probably the most interesting recent developments have been in connection with automatic devices for handling work between machines. This has been a necessary development to allow the production potentialities of in-line transfer machines to be fully used. For example, a set of five machines was designed for machining a V-8 cylinder block at an output of 70 per hour. Four men were engaged in transferring work from machine to machine, but the guaranteed production could not be obtained. Automatic transfer devices were developed for moving work from machine to machine; the output was then obtained and the wages of four men were saved.

Where there is a considerable difference in the cycle times for the faster and slower operations on a component, such as a cylinder block, which has many operations in the machining sequence, it is becoming increasingly common practice to duplicate the machines for the slower operations. Some interesting automatic devices have been developed for feeding the duplicate machines.

In one Ford plant the first operation on a six-cylinder block is performed on a large horizontal broaching machine where the head and sump faces, the main journals and the main bearing locks, are machined in one pass. The output from this machine is 197 blocks per hour. As the second operation has a considerably longer cycle time, the machines for it are duplicated. The system employed is such that each block as it leaves the broaching machine is automatically moved to whichever of the duplicate machines is ready to accept work. From the broaching machine, the workpiece is picked up by a transfer bar for delivery to one machine, or is shuttled broadside to meet a conveyor that feeds the other machine.

At another stage where duplicate machines are necessary to maintain balanced output, there is a turntable directly in line with the first of the duplicate machines. This turntable automatically turns the block through 90 deg, and an electronic controller selects the machine to which the work is to be sent.

When this block leaves the final machining operation, it passes to an interesting two-directional automatic device. The block leaves the final machine with the head face uppermost and the front end leading, but for the early assembly operations it is necessary to have the sump face uppermost and the rear end leading. This change of position is effected automatically by a device in which the necessary compound indexing motion is effected quickly and without shock. When the turnover is completed, an automatic shuttle extracts the block and delivers it to the assembly conveyor.

That American production engineers are satisfied that multi-station in-line transfer machines are an economy, despite their very high first cost and complicated nature, is abundantly proven by the tremendous increase in their use over the past two years. Almost all the tooling for 1955 models of all makes embodies a much greater use of automation than the tooling for previous models, in fact the principle is now applied to almost all components.

EXAMINING COMPLEX NOISE PHENOMENA

A NEW 1/3 octave spectrometer, capable of resolving the whole of a spectrum from 10 c/s to 100 kc/s, is now being manufactured by Salford Electrical Instruments Ltd. It is intended primarily for the examination of complex noise phenomena, but it can also be used for a wide range of applications involving frequency analysis. The instrument comprises a display unit weighing 200 lb and a power supply unit weighing 66½ lb. Both are splash-proof. The cathode ray tube and all valves used are directly interchangeable with American types, and various sub-chassis are readily removable, so that maintenance is simple. Carrying handles and runners are provided on each unit.

For operation the instrument is set up with a suitable pick-up head, and the appropriate frequency range is selected; the instrument incorporates three overlapping frequency ranges: 10 c/s—614 kc/s, 30 c/s—10 kc/s, 320 c/s—100 kc/s. The component parts of the wave form within the range selected are then displayed on the cathode ray tube as a series of vertical lines, the height of each line being directly proportional to the amplitude of its component. In order to facilitate the interpretation of this display, a series of spots derived from a mechanical time base run horizontally across the face of the tube. Each spot is allocated a frequency, and a key giving the appropriate frequency of each spot is mounted immediately below the cathode ray tube. In the design of the equipment, provision has been made for mounting a camera to photograph the display; three lights mounted directly below the tube indicate on such photographs which frequently range is in operation.

The input voltage range is 70 to 120 volts or 200 to 250 volts, 50/60 c/s A.C. An auto-transformer arrangement is used to the 230 volts A.C. required for the motor. Three separate high tension supplies are supplied; one is stabilized. All controls are accessible on the front panel, and the power unit is fitted with micro-switches which make only when the connecting plug to the main is in position. If this plug is not in position, the unit cannot be switched on since the main supply is broken.

The input circuit consists of a cathode follower, which is coupled to a cascade amplifier with a substantially flat response between 10 c/s and 100 kc/s, and also to the grid of the overload and indicator circuit. A cathode follower, which is transformer coupled to the filters, forms the amplifier output; negative feed back is applied to improve the amplifier characteristics. This output is fed into 38 filters, which have their inputs in parallel. With the exception of 10 c/s filter, the circuits of the filters are identical. The output of each filter is passed via a "range switch" either to a crystal diode or direct to a "filters out" switch. Output from the crystal diode feeds a time constant circuit of either one second in the "long time constant" position or 0·1 second in the "short time constant" position. The D.C. output is then passed to the appropriate segment of the filter rotary switch, which has a moving arm mechanically ganged to the time base. Accordingly, the moving arm output consists of a number of D.C. pulses with heights directly proportional to the signal amplitude components. This output feeds the grid of the overload trip valve. It also feeds the output amplifier, which in turn feeds a final amplifier via the filling in circuit in which a high frequency component is introduced to give a vertical line display instead of displaced spots. The output valve is directly coupled to the "Y" plates of a cathode ray tube.

HARD SOLDERING

The Thesscal Process for Aluminium and Aluminium Alloys

R. C. Jewell, B.Sc., A.R.S.M., A.M.I.M.M., F.I.M.*

IT is natural that the accelerating increase in the refining, production, and industrial use of aluminium and its alloys should lead to concomitant intensive study of the available methods of joining sheet, tube, wire, castings, and the like. This study should, of course, embrace new methods of joining as well as improvements in the existing ones.

In 1950, with this end in view, the Sheffield Smelting Company commenced research in its metallurgical laboratories to study the mechanism of corrosion of joints in aluminium and aluminium alloys. The work was directed to finding a new or improved method of joining, not involving fusion of the parent metal, to fill the gap between the existing methods of soft soldering operating at 250 deg C or less, and brazing operating at approximately 600 deg C.

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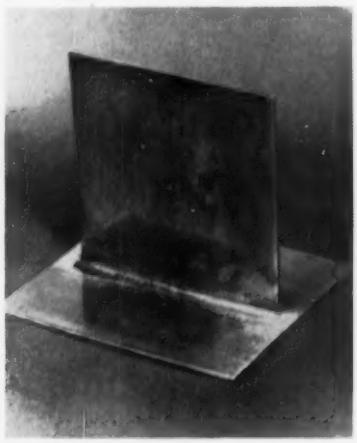


Fig. 1. Duralumin to aluminium joint made with Thesscal 'A' on $\frac{1}{8}$ in thick sheet. Note the neat joint line

The main consideration in making joints by heating is the corrosion resistance and mechanical strength of the joint. Soft soldering, unhappily, does not usually produce corrosion resistant joints, in spite of some 2,000 alloys reputed to have been patented. Generally, the soft soldered joint has low strength, and very often the technique of application can hardly be described as suitable for day-to-day industrial operation.

Brazing enables strong corrosion resistant joints to be made, but the operating temperature, which is above 550 deg C, is too high for joining thin sheet or sections of strong age-hardenable aluminium alloys such as duralumin. There was no method involving heat application of joining between the temperatures 250 deg C and 550 deg C, mainly because no suitable alloys were available for joining aluminium and aluminium alloys in this temperature range.

Research was first directed to fulfilling the essential requirement of corrosion resistant joints, and the mechanism of the corrosion was studied in great detail. This led to the development of the Thesscal process, involving the use of a range of solders and fluxes requiring an operating temperature between 400 deg C and 550 deg C.

The process uses principally two alloys known as Thesscal "A" and Thesscal P.12, which have been proved industrially to be satisfactory for joining aluminium and aluminium alloys, as well as casting alloys, not only to one another but also to dissimilar metals such as copper and its alloys,



Fig. 2. The joint shown in Fig. 1 after hammering. The aluminium parent metal has cracked, but the joint is completely unaffected

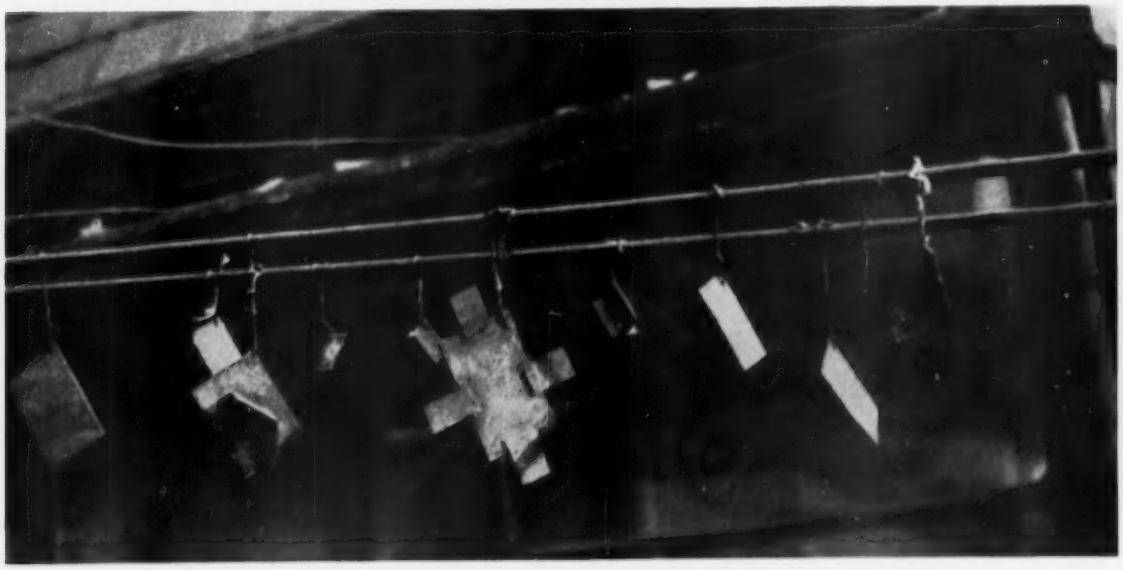


Fig. 3. Soldered joints exposed in the industrial atmosphere of Sheffield for over two years



Fig. 4. A specimen of aluminium joined to aluminium after two years' exposure. The joint is still intact after bending

nickel and its alloys, steel, and even stainless steel. Both these solders have been approved by the Ministry of Supply to specifications D.T.D.900/4376 and D.T.D. 900/4398 respectively, after extensive tests at the Royal Aircraft Establishment, Farnborough, of the corrosion resistance of soldered joints between aluminium and various aluminium alloys. These are the first solders to be approved by the Ministry of Supply for joining aluminium and its alloys.

Thesscal "A" hard solder has a melting range of 420 deg C-450 deg C and is used with flux No. 92. Its main application is on sheet metal and fabricated forms of aluminium and its alloys. This is a free running solder, and the technique of joining is very similar to silver soldering.

Thesscal P.12 hard solder has a wider melting range, namely 440 deg C-510 deg C, and is used with the same flux, No. 92. It is not so free running as Thesscal "A" and can be moulded much like plumber's solder. Its use is principally for aluminium casting alloys, to repair broken castings, build up lugs and protrusions, join castings to sheet metal, and to fill in blowholes or incorrectly positioned drill holes.

These two alloys, having melting ranges between 420 deg C and 510 deg C, have been designated *hard solders* to distinguish them from the lower melting soft solders on the one hand and the higher melting brazing alloys on the other.

The corrosion resistance of joints made with Thesscal "A" and Thesscal P.12 were tested by the standard accelerated tests used by industrial laboratories, and by the Aluminium Development Association to assess the corrosion resistance of joints. These tests were:

(1) Immersion in boiling water for 100 hours minimum.
(2) Suspension in water vapour at 100 deg C for 100 hours minimum.
(3) Immersion in cold 3 per cent salt solution for 1,000 hours minimum.

Tests such as these are very searching and quickly reveal whether the soldered joints are satisfactory from the point of view of corrosion resistance. In addition, salt spray tests were made by the Ministry of Supply prior to the granting of approval. Thesscal soldered joints passed all these tests satisfactorily.

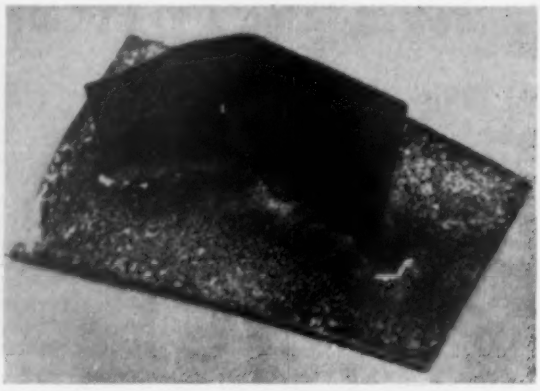


Fig. 5. A joint between aluminium and steel (upper member) after two years' exposure. The joint is still intact after bending

Joints between aluminium and duralumin made with Thesscal "A" were

TABLE I.

Thesscal solder	Melting range deg. C		Ultimate tensile strength ton/in²	Elongation per cent	Electrical Conductivity per cent I.A.C.S.
	Liquidus	Solidus			
"A"	420	450	9·4	5	22·3
P.12	440	510	19·4	4	32·0

TABLE II. STRENGTH OF "THESSCAL" HARD SOLDERED JOINTS IN ALUMINIUM AND ALUMINIUM ALLOYS

SHEAR STRENGTHS

Joint combination	Location of fracture	Shear strength ton/in²
1. Aluminium to aluminium	In aluminium	4·2
2. Al/2 per cent Mg to Al/2 per cent Mg	Part in joint Part in alloy	7·2
3. Duralumin to Al/2 per cent Mg	In Al/2 per cent Mg	8·8
4. Duralumin to duralumin	Mainly in duralumin	9-12·5*
5. Duralumin to copper	In joint	7·1
6. Duralumin to steel	Part in duralumin Part in joint	7·9

ULTIMATE TENSILE STRENGTHS

Joint combination	Location of fracture	Tensile strength ton/in²
1. Aluminium to aluminium	In aluminium	5·1
2. Aluminium to steel	In aluminium	5·1
3. Aluminium to copper	In joint	3·7
4. Al/2 per cent Mg to Al/2 per cent Mg	In joint	7·3
5. Duralumin to duralumin	In joint	8-11
6. Duralumin to steel	In joint	7·3
7. Duralumin to copper	In joint	4·0

**Dependent on aged strength of duralumin*

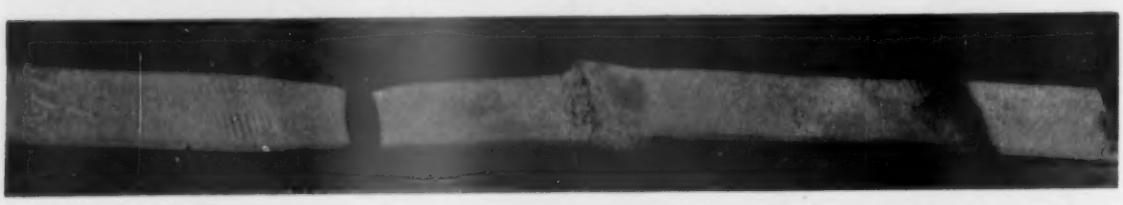


Fig. 6. A lap joint between aluminium and aluminium pulled in tensile test after corrosion testing by immersion in boiling water for 100 hours. Fracture has occurred in the parent metal, but the joint is still mechanically sound

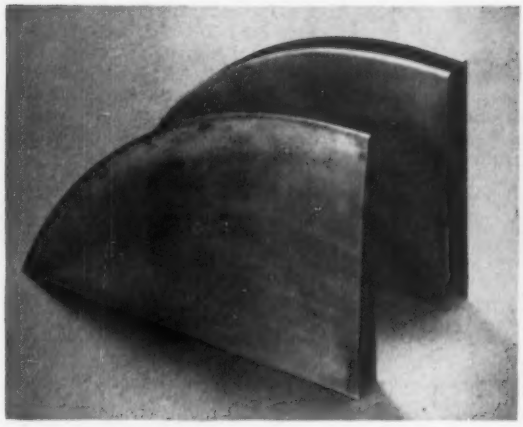


Fig. 7. An aircraft elevator tip consisting of two sheets of 24 gauge Alclad duralumin D.T.D.610B, before and after soldering with Thesscal 'A' and flux 92



Fig. 8. A junction box for instrument panel in aircraft, consisting of aluminium alloy sheets joined with Thesscal 'A' and flux 92. This unit replaces a much heavier casting

subjected to humidity tests to Wireless Telegraphy Board specification K.110, and similar tests lasting nine months were made at the Radar Research Establishment, Malvern. In every case the joints passed the tests satisfactorily. Thesscal soldered joints have also been exposed outside in the industrial atmosphere of Sheffield for more than two years, and are still mechanically sound. Figs. 1-6 illustrate Thesscal soldered joints that have been subjected to mechanical and corrosion tests.

The mechanical properties of the solders are shown in Table I, and typical figures for the shear and tensile strength of joints are shown in Table II. The values given in Table II are averaged from several determinations made on the joints in question. In all cases, Thesscal solder A and flux 92 were used to make the joints. Solder A has the following properties:

Tensile strength .. 9·4 ton/in^2
Shear strength .. 10·4 ton/in^2

The shear strengths of Thesscal soldered joints are distinctly high and much greater than obtainable with soft solders. Note particularly the high value for the soldered joint between duralumin and steel. In general, joints between commercially pure aluminium and the range of materials shown in Table II would fail in the aluminium when tested to destruction under shear stress.

The technique of application involves heating with a simple hand torch, using any combination of gases such as air-coal gas, oxy-coal gas, oxy-hydrogen, and oxy-acetylene. It is being used successfully in research and production departments of many industrial firms, Ministry of Supply factories, universities, and research organizations.

Mass production techniques of Thesscal hard soldering, using electro-gas, furnace, high frequency, dip, and salt bath, are being investigated, and research to this end is being carried out by the Sheffield Smelting Company in conjunction with industrial users.

The field of application of the Thesscal process is very wide. A complete range of aluminium alloys can be joined successfully, including aluminium - manganese, aluminium-magnesium, duralumin, and casting alloys, including L.33. These alloys can be joined to one another and to copper, brass, phosphor bronze, tungum, gunmetal, nickel silver, steel and stainless steel.

One important use is for equipment and for unstressed or lightly stressed parts in aircraft, where the low operating temperature of about 450 deg C for Thesscal "A" enables thin sheet and sections of duralumin to be joined by unskilled labour without fear of fusion. One aircraft firm is using the process for joining Alclad duralumin for elevator tips where thin gauge duralumin has replaced the previously used welded joints in aluminium, which had to be of much thicker gauge to give the required strength. This has resulted in a considerable saving in weight.

Brazing cannot be used on thin gauge duralumin because of the danger of fusion, since the melting point of the brazing alloy is too near the melting range of duralumin. The lower operating temperature of the Thesscal process enables such thin gauge duralumin to be joined by unskilled operators, including girls, with complete confidence. Moreover, the risk of distortion is greatly reduced, and in most cases completely removed.

Fig. 7 shows an aircraft elevator tip consisting of two sheets of 24 gauge Alclad duralumin D.T.D.610 B before and after soldering with Thesscal "A" and flux 92. This illustration is shown by courtesy of The Fairey Aviation Company Limited, Stockport.

Fig. 8 shows a junction box for instrument panel in aircraft, consisting

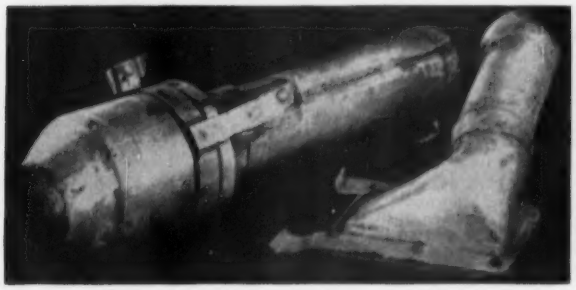


Fig. 9. A heat exchange unit in the form of ducting fabricated from 0·028 in thick aluminium sheet and $\frac{1}{8}$ in thick strips. This unit has been in service in a road vehicle for three years without any sign of damage to the Thesscal soldered joint



Fig. 10. A small tank of aluminium soldered to a copper pipe by the Thesscal process and subjected to pressure testing at approximately 80 lb in^2 water. Note that the ends have cambered without any failure of the soldered joints

of aluminium alloy sheets jointed with Thesscal "A" and flux 92. It replaces a much heavier casting which had to be used previously, with the result that a considerable saving in weight has been achieved. This unit is in production at the Bradford works of The English Electric Co. Ltd., by whose courtesy the photograph is shown.

Fig. 9 shows a heat exchange unit in the form of ducting fabricated from 0·028 in thick aluminium sheet and $\frac{1}{8}$ in thick strips. This unit has been in service in a road vehicle for three years without any sign of damage of the Thesscal soldered joints at any point. The unit has been subjected to heavy vibration throughout all weather conditions, both in summer and winter. Fig. 10 shows a small tank of aluminium soldered to a copper pipe by the Thesscal process and subjected to pressure testing at approximately 80 lb/in^2 in water. Note that the ends have cambered without any failure of the soldered joint. Figs. 9 and 10 are published by courtesy of Messrs. Metropolitan Vickers Electrical Co. Ltd.

Heat exchangers for aircraft and guided missiles are other examples where the process can be used to advantage. The process can also be applied for joining a variety of equipment for aircraft, radar, medical, domestic, and industrial service. Dissimilar metals, such as steel to aluminium, can be joined successfully to combine the lightness of aluminium with the strength of steel. Many new possibilities are thereby opened up and design departments can take advantage of this unusual combination to produce lighter and stronger components. Examples are turbine housings and tractor cab housings. Aluminium can be joined to copper quite easily.

Model engineers can make models in aluminium and aluminium alloys with the same facility as they are accustomed to when using brass with silver soldering. In the foundry, castings and patterns in aluminium and aluminium alloys can be repaired, built up, or corrected with greater ease, since the only equipment necessary is a simple hand torch, and strong corrosion resistant joints are assured. The motor repair industry is using the process for repairing car bodies, etc.

There are two considerations which have to be taken into account when using the process. The first is that the flux is corrosive and must be washed off the joint. This is common to silver soldering where fluoride flux is similarly corrosive. The Thesscal flux, however, has the advantage of being extremely soluble in hot water, much more so than silver solder flux. The second is that Thesscal soldered joints cannot be anodized because they are attacked chemically by the anodizing solution. This can be overcome by using proprietary stop-off lacquers prior to anodizing. Where some form of protection of the whole assembly is called for by specification, etching primers and paints can be used quite successfully. This alternative method is approved by the Ministry of Supply.

Patent applications for this process have been made both in England and abroad by the Sheffield Smelting Company, who are the sole manufacturers of the Thesscal solders and fluxes. This paper is published by kind permission of the directors of Sheffield Smelting Company Limited.

WHO'S WHO

THE second edition of *Who's Who in the Motor Industry* is now available from the publishers, Roland C. Bellamy Publications, Saint Mary's Gate, Grimsby, Lincs. at a price of 27s. 6d. When the first edition appeared in the autumn of 1952, it was quickly realized that a work of this character had long been needed, and to-day there must be many who find that this compendium of information is an invaluable reference work.

This edition runs to 881 pages, comprising three main sections. The first section of over 300 pages, provides a comprehensive list of firms engaged in or connected with the automobile industry, but the real value of this section is that the information about each entry invariably includes a complete list of the directors and in most cases also names the chief executives.

The second section, of almost 500 pages, provides biographical information about a host of people connected with the motor industry in many different fields of activity. Finally, a section of some 30 pages gives a comprehensive list of trade associations and professional institutions connected with the motor industry and their aims and objects; a list of newspapers and journals detailing what coverage is given to automobile matters; and short biographies of some of the leading technical journalists and motoring correspondents. A key list is also given for identifying the many abbreviations used in this work.

TRADER HANDBOOK

IN the *Trader Handbook*, 1955, which incidentally is the 49th edition of this invaluable work, there are six sections: technical and general (motor); technical and general (motor cycle and cycle); transport service equipment; buyer's guide; proprietary names; trade addresses. The sections are divided by guide cards with thumb indexes for easy reference.

Lists of vehicle manufacturers with vehicle specification details, fill-up, front end service, nut tightening torque data and oil producers' S.A.E. numbers are given in the technical and general (motor) section. This section also includes lists of suppliers of spare parts, and of repairers, wholesalers and trade associations. A legal guide and an index of vehicle registration numbers are also included. Information of a similar character applying to three-wheelers, motor cycles and pedal cycles is given in the technical and general (motor cycle and cycle) section.

Under transport service equipment there is an up-to-date list of firms specializing in the manufacture or sole distribution of garage and workshop equipment for manufacturers and repairers. Manufacturers and sole distributors of motor cycle and cycle accessories are listed in the buyers' guide, and approximately 5,000 proprietary names attached to such products are identified in a separate section. The trade addresses section has been completely revised. It deals with all manufacturers, concessionaires, distributors and wholesalers mentioned in the work, giving their postal and telegraphic addresses and telephone numbers. Where possible the names of the sales and service managers are also given; very useful information.

Bound in paper-boards, this 432 page work is published by Trader Publishing Co. Ltd., Dorset House, Stamford St., London, S.E.1, at 15s. net (by post 15s. 6d.).

EPIKOTE RESINS

IN recent years there have been major advances in the development of synthetic resins. Among the most important of these are the "Epikote" resins produced by the Shell group. At present the main use for them is in surface coatings, including paints, lacquers, stove enamels and varnishes, but they also have potentialities as castings and laminating resins.

In surface coatings, "Epikote" resins are of great importance because they combine the desirable properties of adhesion, flexibility, toughness and resistance to chemicals in a degree that hitherto it was impossible to achieve in a single finish.

In general, "Epikote" based coatings impart harder wearing finishes than have been practicable in the past. The fire risks with these coatings are less than with nitro-cellulose lacquers, and in heat resisting properties "Epikote" finishes are superior to most of the conventional coatings.

LUBRICATION

Notes on Types and Sources of Lubricants

TO meet the complex and exacting demands of modern machinery, large numbers of lubricants have been gradually evolved, and to-day lubrication engineering is a highly specialized science. The oil technologist, therefore, plays an important role in industry, particularly in developing lubricants to meet requirements of new designs of machinery. Designers of machinery cannot be expected to have the specialized knowledge necessary for specifying the best type of lubricant for a specific application, but some knowledge of the various types of lubricants and their properties is desirable. These notes, which are based upon a memorandum issued by the Petroleum Information Bureau, deal briefly with these matters.

Normally, oils are used to provide lubrication, but semi-solid greases and even solid lubricants are employed for certain purposes where the use of an oil is difficult or unsatisfactory because of exceptional circumstances. The main sources of lubricants are:—petroleum oils, fatty oils (of animal or vegetable origin), crystalline solids (from which solid lubricants come) and chemicals from which synthetic lubricants are manufactured.

Although lubricants represent only a small proportion of all the refined products obtained from petroleum, oils derived from this source account for about 90 per cent of all lubricants. In comparison with materials obtained from other sources, petroleum derivatives are available in very large quantities. They also yield lubricants of very high quality, ranging from extremely thin fluid suitable for very delicate mechanisms to thick oils and semi-solid materials. As different mineral oils can easily be blended together, there is a very wide variety of viscosity. The crude oils from which lubricants are derived may be divided into three main classes:—paraffin base, naphthene base, and mixed base.

Types of lubricants

Paraffin base crudes contain paraffin wax but little or no asphaltic matter. They usually give good yields of high grade lubricating oils. The crudes found in Pennsylvania, U.S.A., are typical of this class.

Naphthene base crudes, sometimes called asphaltic base crudes, contain asphaltic bitumen but little or no paraffin wax. Because of their particular qualities, lubricants of naphthenic origin are more suitable for certain applications than those derived from paraffinic crude. Naphthene base crudes are found in many countries, including the U.S.A., Venezuela, and Rumania.

Mixed base crudes contain both wax and bitumen. They have characteristics intermediate between those of paraffin and naphthene base crudes. While the lubricating oils manufactured from them may be either paraffinic or naphthenic in nature, in practice mixed base crudes generally produce oil similar in characteristics to those obtained from paraffin base crudes. Mixed base crudes are found in Iraq, Venezuela, and parts of the U.S.A. among other places.

Fatty oils are rarely used nowadays as lubricants for modern machinery. They are, however, blended with mineral oils to form compounded oils. As a rule, a compounded oil contains only small quantities (less than 10 per cent) of fatty oil, which is generally added to make the oil emulsifiable with water. In addition, fatty oils are sometimes used for making the soaps required in the manufacture of lubricating greases.

Certain inorganic solids form a special class of lubricant. Of these, the outstanding examples are: graphite, molybdenum disulphide, talc, mica, chalk and lime. Although they do not reduce friction to the same extent as lubricating oils, they prevent scoring and damage to the metal. Furthermore, by virtue of their resistance to heat they are often of value at high temperature; this is particularly true of graphite and molybdenum disulphide. Because their solid nature makes them difficult to apply uniformly, these lubricants are usually incorporated in a carrier such as water, oil or grease.

Finally, there are the synthetic lubricants. These are of comparatively recent development. They are compounds which have been built up or synthesized in the chemist's laboratory. Among other types, they include the well known silicones in which a chain of carbon atom is replaced by alternate silicon and oxygen atoms. While each of the synthetic lubricants is superior to mineral oil in some respect, each also has certain disadvantages and all are more costly than mineral oil.

Lubricating oils

The most important property of the lubricating oil is its viscosity—that is, its resistance to internal fluid friction —which enables it to separate two moving parts in an engine or bearing and make and maintain a condition of fluid film lubrication. In general, the slower the movement, the higher the viscosity of the oil must be. Viscosity may vary considerably with temperature. This variation is indicated by the "viscosity index," and the higher this index is, the smaller the variation in temperature changes. Oil with a high index is important for applications where large temperature changes occur, as, for example, in the internal combustion engine of a motor vehicle. Lubricating oil must also have sufficient stability to resist chemical changes such as oxidation, which leads to thickening of the oil and the formation of petroleum acids and sludge.

For certain applications, it is necessary to augment the natural properties of petroleum oils with additives. Those most commonly used include anti-oxidants, anti-corrosive agents, detergents, anti-wear agents, extreme pressure additives, viscosity index improvers, and anti-foam agents. For many applications, however, straight mineral oils are quite suitable and are still used.

Lubricating greases

Lubricating greases commonly consist of mineral oils thickened to a solid or semi-solid consistency by the addition of metallic soaps. Technically speaking, they are a "dispersion" of soap in oil. Sometimes fatty or synthetic oils are used instead of mineral oils. Small quantities of other materials are included to help prevent the oil and soap from separating out.

A very important factor in the making of lubricating greases is the choice of oil and soap to be compounded. The soap is normally obtained from animal or vegetable fats mixed with a suitable alkali, a calcium (lime) or sodium (soda) base being the most common. However, aluminium and lithium are also frequently used, and for special purposes lead or barium may be employed. The methods employed in forming the soap, and the temperatures used in making the grease, vary considerably and result in the production of two main types of greases, "boiled greases" and "cold-sett greases." A process by which cold-sett greases are made is very simple and cheap, but the quality of the grease is much lower than that of a boiled grease.

There are many applications where there is little to choose between the performance of a grease or an oil, but generally greases are used where it may be difficult or inconvenient to maintain a supply of oil. Greases are also better able to exclude moisture, dust, corrosive gases, etc., particularly in ball or roller bearings. They are also suited for use in slow moving heavily loaded bearings with relatively large clearance where the condition of fluid film lubrication is unattainable with an oil.

Types and properties of greases

Lubricating greases are usually classified according to their consistency, which ranges from a hard block down to "liquid greases" closely resembling ordinary oils. The consistency of the lubricating greases affects the method of application. The melting point of a grease, at which it loses its typical semi-solid character, is important; so is its resistance to water. Other properties include the apparent viscosity —if a grease is applied to a bearing it has a high apparent viscosity so long as the shaft revolves slowly, but as the speed of the shaft increases, the apparent viscosity falls and the grease behaves more and more like a liquid. This effect, by the way, is not due to any rise in the temperature of the bearing.

The consistency and other properties of a grease depend upon both the viscosity of the lubricating oil and the amount and type of soap used. Choice of soap is particularly important. Thus, a calcium soap gives greases with a wide range of consistency and smooth texture, which are unaffected by water, whereas sodium soap greases generally have a rather spongy texture and tend to emulsify in the presence of water. They can, however, be used at higher temperatures than calcium soap greases.

Greases with an aluminium soap have a smooth texture and a transparent appearance. They adhere well to metal, have good water resistance and can be used up to relatively high temperatures. Lithium soap greases have a smooth buttery texture and are resistant to water. They also maintain their consistency over a wide temperature range. In addition to these four main types, there are greases with a lead soap which resist high pressures, and barium soap greases which have a slightly fibrous texture, a high melting point and are water resistant.

It is thus possible to manufacture a very wide range of lubricating greases with very different properties. For special purposes, additives may be incorporated, as in the case of lubricating oils. A few examples may be given to indicate how different greases are designed for different uses.

Grease applications

Gear greases are normally of the sodium, or aluminium soap, types, with a wide range of consistencies. The aluminium type greases are specially useful because they adhere firmly to the metal. Greases intended for use with heavily loaded gears will incorporate extreme pressure additives.

Anti-friction bearing greases may be of any of the four main types. To prevent oxidation they sometimes contain oxidation inhibitors. Where the grease is liable to be washed away through contact with oils or chemical solvent, graphite may be incorporated, but if the grease is to be used for anti-friction bearings, the graphite must be in finely divided colloidal form.

A multi-functional lubricant may be used for all grease lubricated parts of a car chassis. Alternatively, separate greases may be used for the various applications involved. Sodium soap greases, with a texture made up of long soap "fibres" which gives them good adhesive and cohesive properties, are suitable for use in universal joints. By way of contrast, wheel bearing lubrication is often effected with "short fibre" sodium soap greases. For the steering gear, rather high consistency greases are used. They are made from viscous oils with a small proportion of calcium, sodium, or aluminium soap, and they also include an extreme pressure additive. Greases for grease gun application are mostly of calcium, sodium or aluminium types, with moderate consistency.

Greases used in water pumps and other machinery where frequent contact with water is experienced, are normally of the calcium type. Very different indeed are the block greases, which are shaped to fit into bearings running at high temperatures in industrial plant or locomotives. They also contain a calcium or sodium soap, but are exceptionally hard and have a high melting point.

The oil industry acts in close collaboration with engine manufacturers and as mechanical advances in design are made, the oil technologists study the lubrication problems that will arise. A lubricant to meet the requirements of the new engine is developed and is finally tested under full scale operating conditions. Every possible precaution is taken to ensure that mechanical developments will not be held up through lack of a suitable oil. One oil industry research station in this country owns and operates a fleet of motor cars, employed solely to further research into the behaviour of different lubricating oils under actual service conditions. From time to time, the cars are completely stripped and examined for wear and damage. The memorandum from which these notes have been extracted is available, free of charge, from The Petroleum Information Bureau, 29 New Bond Street, London, W.1.

CHEMICAL MILLING LIGHT METAL

A PROCESS with considerable potentialities has been developed by North American Aviation Inc. It employs etching to produce complex shapes and asymmetrical patterns that hitherto have been produced by machine milling. The process, which is known as "Chem-mill", is said to have two great advantages, particularly for aluminium parts for aircraft. They are:

(1) It permits engineering design advantages which result in lighter construction.

(2) It yields operational advantages which lead to lower cost per part. Among the chief of these advantages are the possibility of batch production and the fact that etching equipment is said to cost less than 7 per cent of the cost of skin milling equipment.

The Chem-mill process consists in partially masking the work with a chemically resistant coating, after which the coated material is submerged in a modified hot alkaline solution, which removes metal in the unmasked areas. Successful tests have been made on aluminium, titanium, carbon steel and stainless steel.

The successes are attributable to three factors:

(1) The development of new organic coatings and tapes resistant to hot alkaline solutions.

(2) Compounded or modified etching solutions which give uniform etching rates without destroying the physical or chemical properties of the metal.

(3) Electronic measuring and control equipment.

Chemical milling is suitable for many different applications. It can be used for producing complex contours, and in working with sheet it is claimed that tolerances can be held as close as 0·002 in. The process can be used for tapering sheets, extrusions, top-hat sections and other forms suitable for stiffeners in such a manner that design stresses can be transferred proportionately as required. By progressive unmasking, the chemical milling process can be used to produce various depths of cut on large areas of one sheet.

A factor of great manufacturing importance is that the number of parts that can be etched simultaneously is limited only by the size of the tank. Furthermore, finished Chem-milled parts require no further finishing process such as sanding or polishing.

Etching costs vary with the type of masking techniques required. For forgings and other parts requiring no masking, costs are said to be in the region of 27 cents per pound of aluminium removed. This compares with approximately one dollar per pound for machine-milled parts.

Simple and economical masking by chemically resistant templates is possible for parts without cross ribs or stiffeners. Higher costs are involved for the various masking techniques using tape, paint spray, silk screen process, photo-sensitive coatings or metal plating. These techniques are employed chiefly for parts of more intricate design. The amount of metal removed during Chem-milling can be determined while the part is still in the tank.

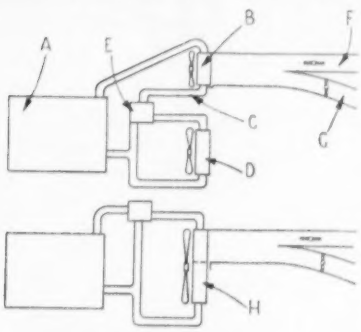
CURRENT PATENTS

A Review of Recent Automobile Specifications

Heating installation

THIS car heating system is distinguished by the provision of a blower or fan having a steplessly variable speed transmission in its drive or, alternatively, adjustable blades. Heat is taken from the engine coolant either by a separate radiator or by a portion of a common radiator. In one arrangement heated water from the engine A is conducted through radiator B and thence, by way of pipe C, to radiator D. A thermostatically controlled valve E can, at low water temperatures, by-pass radiator D by returning the water directly to the engine by way of the usual short-circuit pipe. Each radiator is served by a fan but only that for radiator B is controllable.

Air warmed in radiator B is delivered to a duct which branches into a duct F leading to the interior of the body and a duct G discharging to atmosphere. The throttle valve in duct F is adjusted manually while that in duct G may be automatically regulated by air pressure against



No. 711909

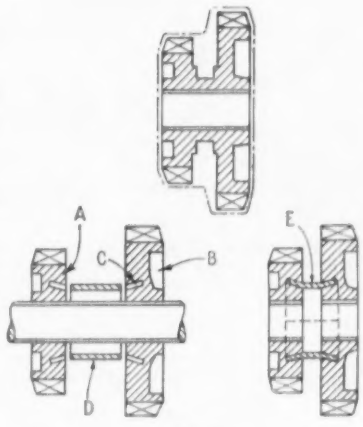
a loading spring, or by a pressure-sensitive capsule located in the main duct.

Control of the heating effect is exercised by regulation of the fan speed or the fan blade angle by a temperature-responsive or a pressure-responsive element in the main warm air duct. Alternatively, the fan may be regulated in dependence upon the engine coolant temperature, in which case it may be controlled by valve E.

In the modified arrangement the two radiators are combined in a single unit H and served by a common fan. *Patent No.* 711909. *F. Nallinger* (*Germany*).

Production of sliding double gears

DOUBLE wheels for change-speed gears are commonly produced on chucking automatics or turret lathes from upset forgings or stampings. This involves a considerable amount of machining and loss of material. On the resulting blank the smaller wheel must be cut individually and usually its teeth cannot be ground. The sketch shows a finished gear with the stamping shape indicated in broken outline. For more convenient and more economical production it is proposed to form and cut the wheels separately and to join them by a connecting element that also serves to define the striking fork groove.



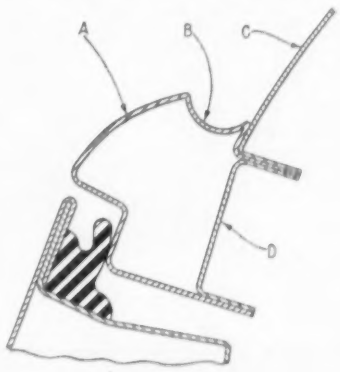
No. 713587

Slab wheels A and B are machined by any convenient method and can be ganged for tooth cutting and, if desired, for tooth grinding. Each is formed on an appropriate face with a cone-shaped annular recess C. The connecting sleeve D may be either a tube or sheet material rolled to tubular shape. With the wheels aligned on a suitable fixture the three parts are press-assembled, the ends of tube D being forced into the recesses C to give a permanent and non-slipping connection, as shown at E. *Patent No.* 713587. *F. Porsche* (*Germany*).

Roof construction

BY this method of construction the assembly of the roof rail and the roof panel provides a built-in drip trough and the usual separate drip moulding can be eliminated. Roof rail A is formed along its upper surface with an integral gutter B. Inwards of this gutter the rail is furnished with a marginal flange which is sandwiched between and welded to the marginal flange of the roof panel C and the flange of the inner roof rail channel D.

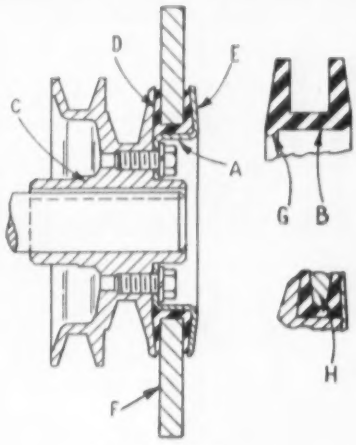
The gutter is formed wholly in the roof rail and effectively conceals the junction of the roof panel with the roof rail. It extends from the front pillar, over the door or doors and the rear quarter, to the waistline. *Patent No.* 713504. *Ford Motor Co. Ltd.*



No. 713504

Torsional vibration damper

OF the type having an inertia mass connected to the shaft by a rubber body, this damper is of simple design and well adapted to low-cost mass production. In the example illustrated, the damper is combined with a twin pulley for driving the engine fan and the generator. A stamped metal retainer A for the rubber body B is registered on hub C and secured by screws. Both the radial face D of the hub and the radial flange E of the retainer are inclined from a plane normal to the axis and the space defined by these faces decreases with increasing radius. Both faces are slightly lipped at their peripheries.



No. 712263

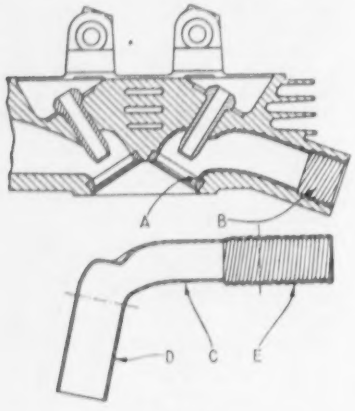
The U-section annular rubber body B receives the inertia member F which has the form of a flat ring with parallel side faces normal to the axis. Relative angular movement between inertia member F and rubber B, and between rubber B and hub C, is prevented by friction rather than by surface bonding. In the free state, the base width of rubber B is greater than the clearance between the confining flanges, this excess consisting mainly of an increased thickness of the radial flanges of the rubber. Thus the clamping of the rubber by retainer A compresses the annular base of the rubber and the rubber flanges are caused to flow radially. Since the spaces between the faces of the inertia body and the confining flanges decrease with increasing radius, there is resistance to radially outward flow. This configuration also resists outward flow under the influence of centrifugal force. A feature of the rubber body is the radial lip G which fills the void between face D and the radiused attachment flange of retainer A.

In a modified construction the confining flanges may be parallel and the side faces of the inertia body tapered towards the axis, as at H. *Patent No.* 712263. *H. A. King* (*U.S.A.*)

Sheet-metal linings for cylinder head gas passages

A SMOOTH interior surface is ensured for the inlet passage of a cast cylinder head by the provision of a relatively thin sheet-metal lining. Although it is not so important for the exhaust passage to be lined, it may, if desired, also be furnished with a similar lining. As shown in the illustration, the inner end of the lining is flush with the bottom face of the recess in which the renewable valve seat A is accommodated. It thus provides additional support for the seat and prevents it being hammered into the relatively soft metal of the cast head. The other end may be formed as a screw thread B, which is preferably produced by a rolling process.

As some difficulty may be encountered in producing the lining to the required shape in a seamless iron tube, it is proposed to form it in halves pressed from sheet iron which are subsequently joined by soldering or welding. The joining operation is performed in a protective atmosphere to prevent the formation of scale and to retain the smooth metal surface. Initially, the tube C is produced



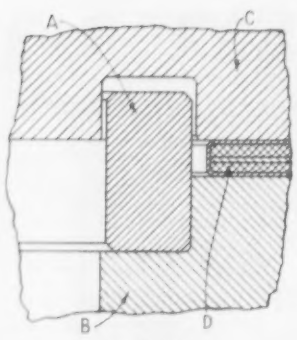
No. 713109

to a greater length than is required in the finished assembly. The excess portions D and E serve as prints for supporting and precisely locating the tube in the chill mould in which the cylinder head is cast. These portions are trimmed off when the head is machined. *Patent No.* 713109. *N S U Werke A.G.* (*Germany*).

Protecting a cylinder head gasket

FROM time to time a variety of suggestions have been mooted or tried out experimentally to protect the edge of a cylinder head gasket from the pressure and action of combustion gases. Schemes involving a recess in the cylinder or head entered by an annular projection on the corresponding member had the disadvantage of precluding the smooth machining of the joint surfaces. Gaskets furnished with annular inserts of solid metal were limited in the extent they could be compressed and were liable to make less than a perfect seal at the coolant apertures between cylinder and head.

In this invention a metal ring A is shrunk in a recess in the cylinder B and projects beyond the face of the cylinder into an annular groove in the head C with clearance on all sides. It is a feature



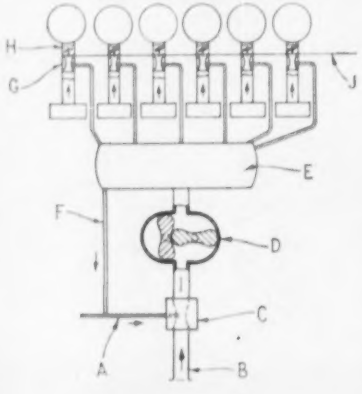
No. 713307

of the invention that the edge of the gasket D is disposed at a distance from ring A so that it does not acquire the temperature of the ring under working conditions. To ensure that thermal tensions in the ring, which normally is of greater axial length than radial thickness, are not transmitted to the cylinder head, the axial clearance of the ring is greater than its radial clearances. Owing to the labyrinthine character of the passage formed between the ring and the cylinder head groove, the gasket is well protected from the combustion gases. *Patent No.* 713307. *Daimler-Benz A.G.* (*Germany*).

Gas distribution in multi-cylinder engines

IRREGULARITY in the distribution of combustible mixture to the cylinders of an engine tends to increase with the number of cylinders. A plurality of carburettors and elaborate manifolding cannot completely overcome the irregularity and prevent differences in the mixture ratio in the various cylinders. In the scheme shown diagrammatically a rich mixture is produced in a carburettor common to all cylinders and delivered under pressure to each cylinder, where it is mixed with air induced by that cylinder to form the final mixture.

Fuel through pipe A and air by way of intake B are drawn into the carburettor C by a positive-displacement blower D and the resulting rich mixture is delivered to an equalizing tank E. Means may be provided for heating this tank when desirable, and any condensate is returned to the supply by pipe F. From the tank



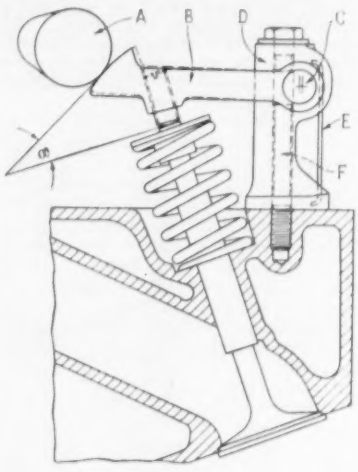
No. 712796

a relatively small diameter pipe conducts a restricted quantity of rich mixture to the venturi G of what is virtually a gas carburettor on each cylinder. Air drawn into the cylinder dilutes the rich mixture and the resultant mixture is admitted to the cylinder past an independently adjustable throttle valve H. These throttle valves may be linked to a common control J.

As modifications, the specification covers the provision of a rich mixture carburettor for a group of cylinders instead of for all cylinders and the supply of rich mixture to a group of cylinders instead of to individual cylinders. *Patent No.* 712796. *Daimler-Benz A.G.* (*Germany*).

Compensating rocker gear for O.H.C. engine

BETWEEN cold and hot conditions of an overhead camshaft engine there is likely to be considerable variation in valve clearance, particularly in the case of the exhaust valve, owing to thermal extension of the valve stem. This rocker



No. 713579

gear provides an automatic compensation to counteract this variation.

The camshaft A actuates the valve through the medium of an interposed rocker B pivoted on a shaft C supported in a bearing bracket D. At its extremity rocker B has a profiled face for engagement by the cam and adjacent the extremity is the adjuster screw that abuts the end of the valve stem. In combination the parts constitute a "wedge" of α angle. Bracket D, of a light alloy, is asymmetrical about its bolt axis, with its greater mass on the side adjacent the valve. On the other side a strap E of steel, linking upper and lower ends of the bracket, is cast-in. The steel securing bolt F is so proportioned as to be capable of flexing slightly.

In operation the valve stem expands under the influence of rising temperature and tends to take up the running clearance. At the same time the bracket D tends to expand and, against the constraint of bolt F, to flex away from the valve. Thus the rocker is withdrawn from the cam and, owing to the wedge-like disposition of the parts, the running clearance is restored. *Patent No.* 713579. *Daimler-Benz A.G.* (*Germany*).

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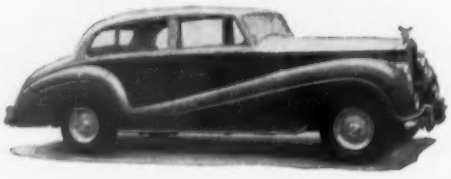
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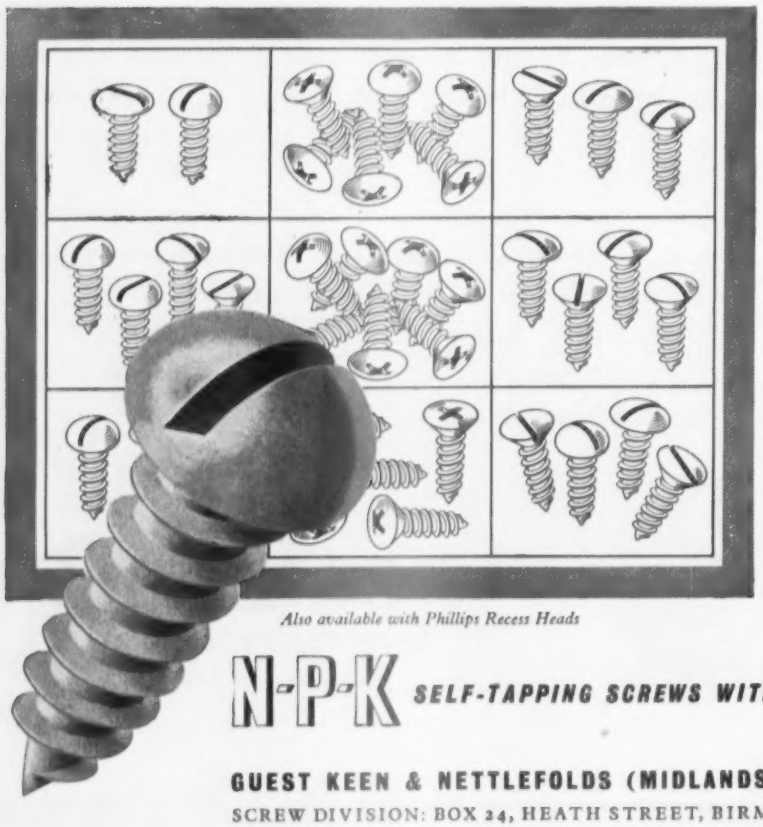
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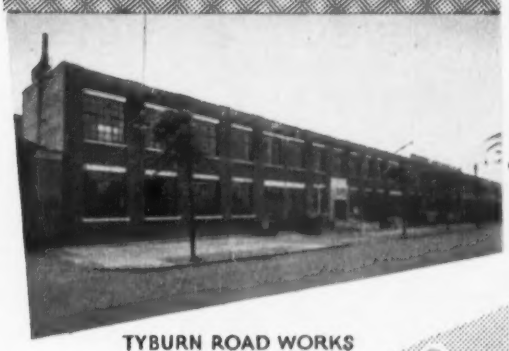
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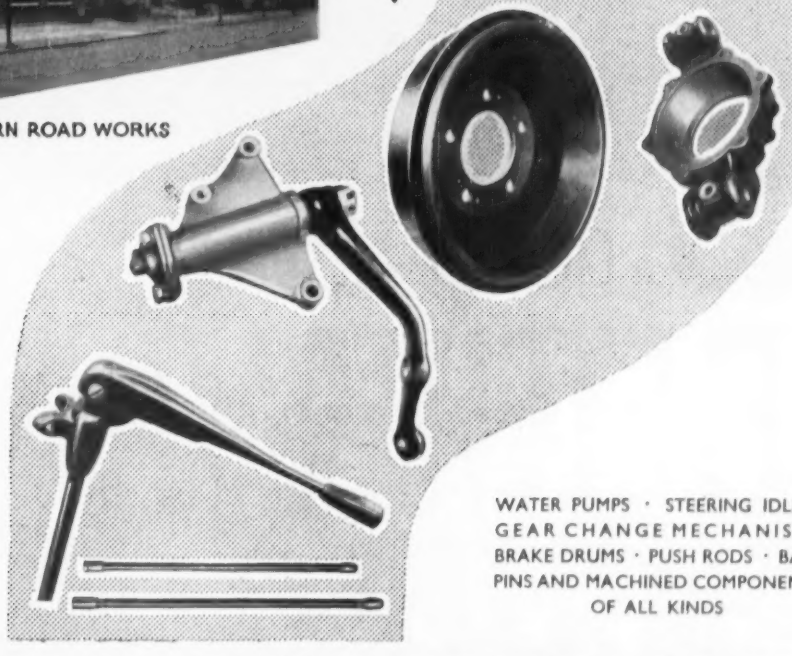
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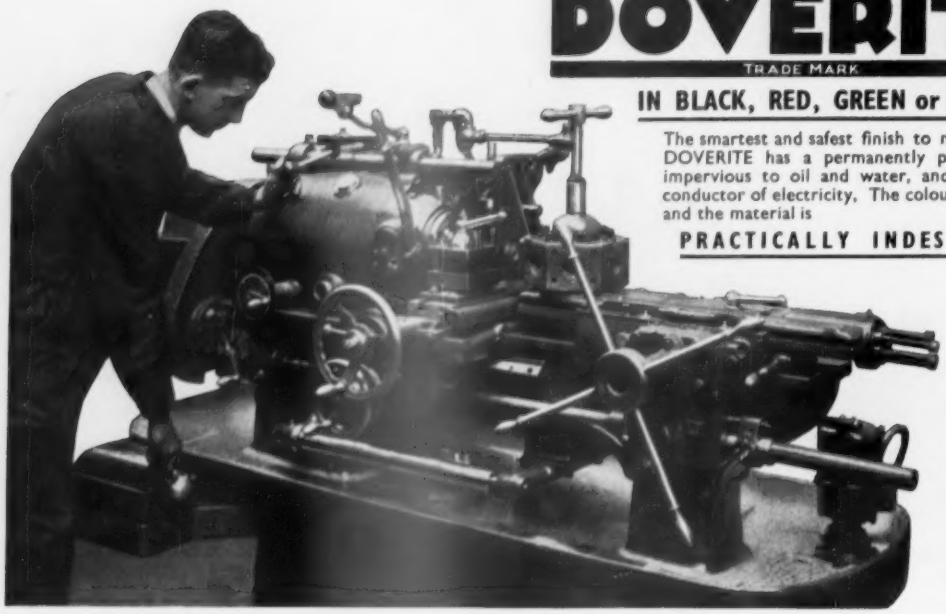
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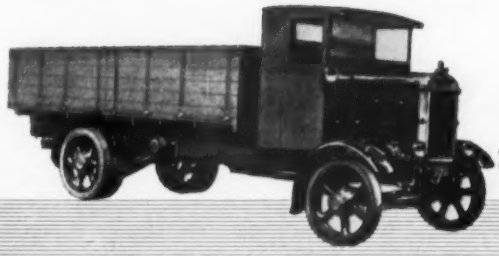
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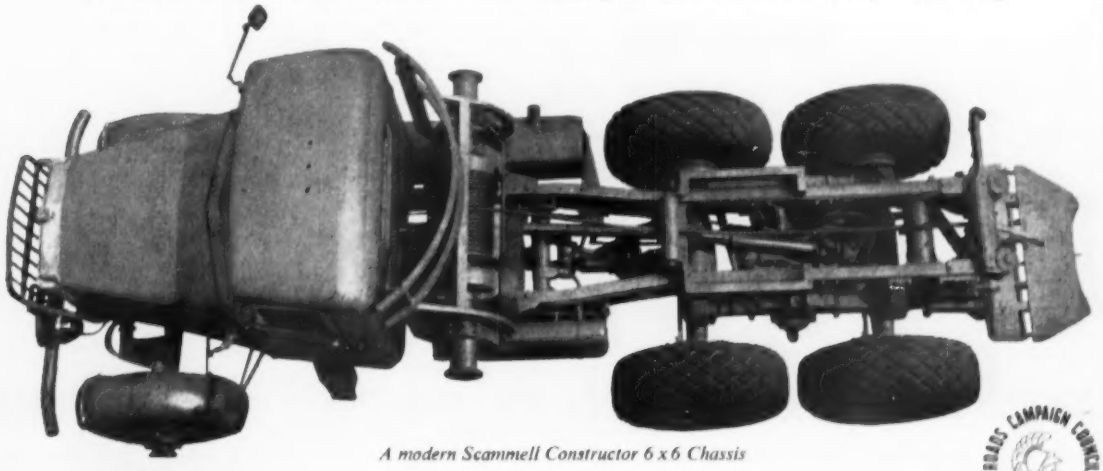


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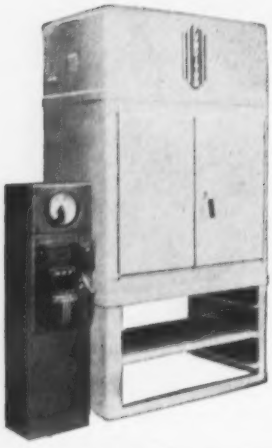
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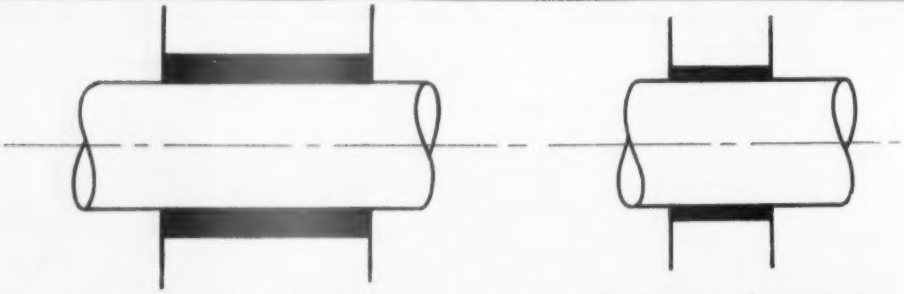
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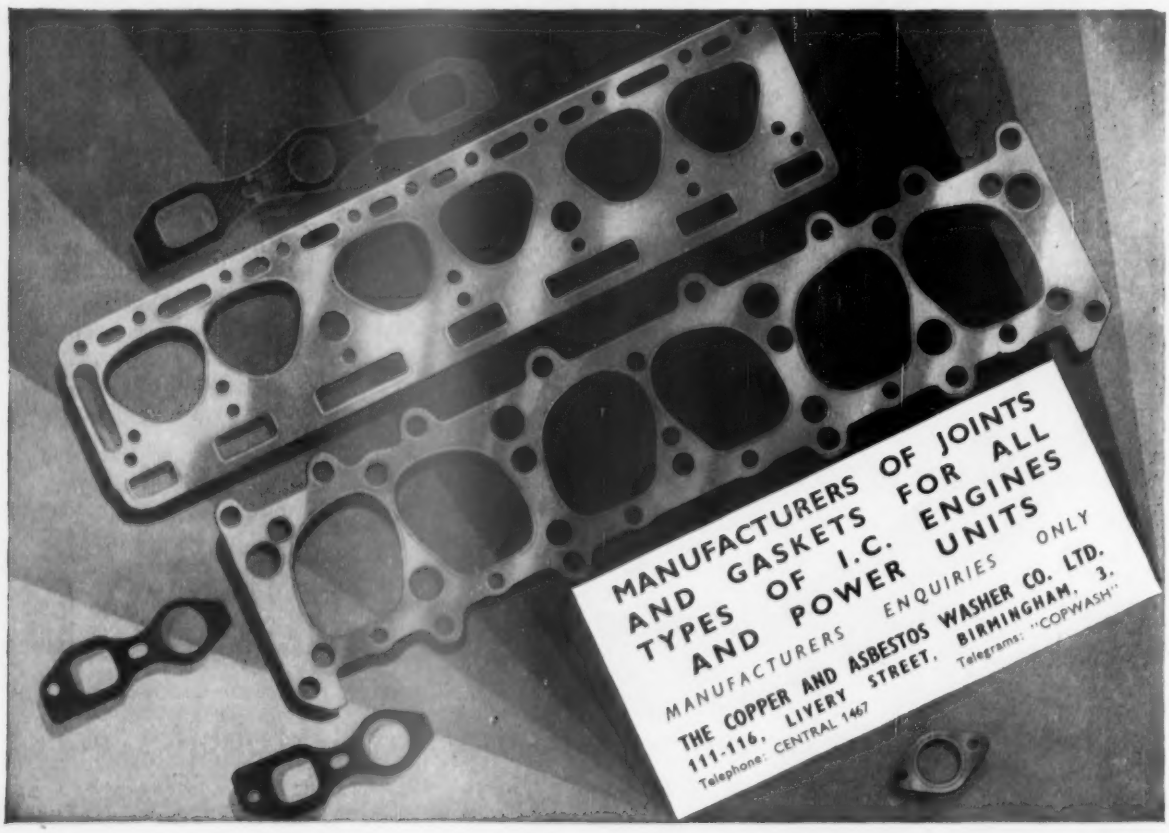
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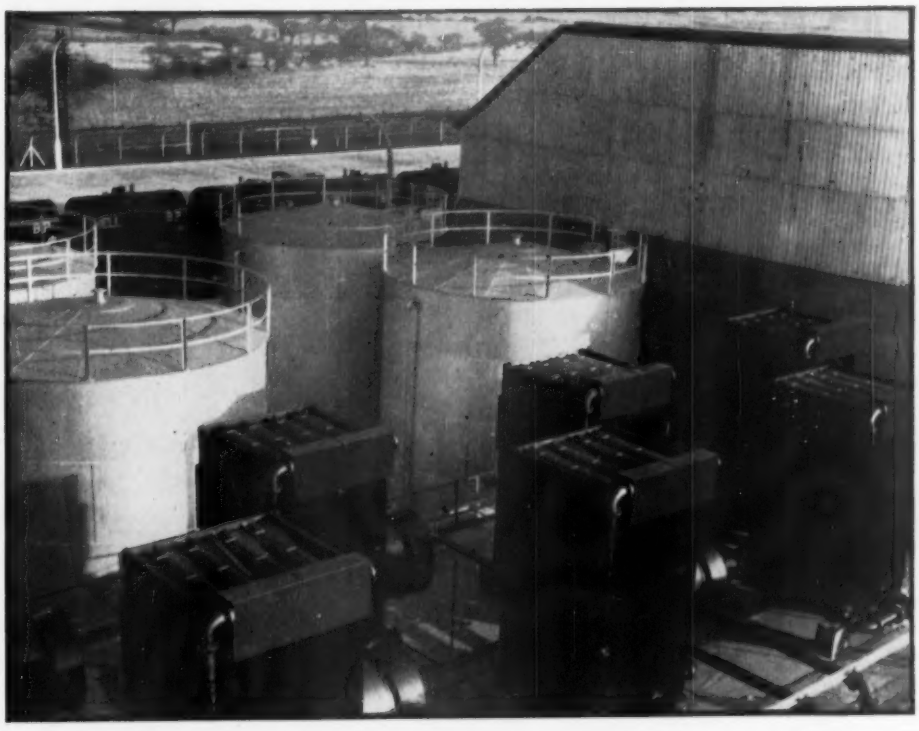
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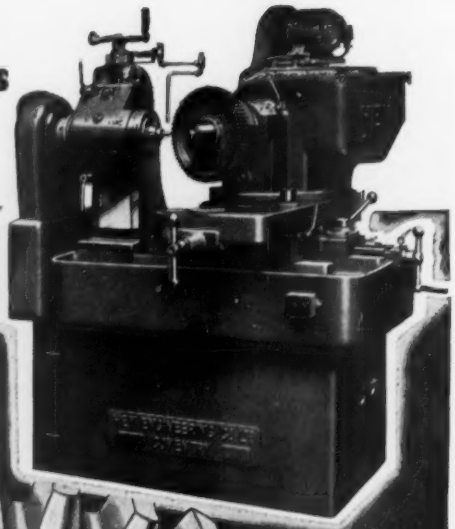
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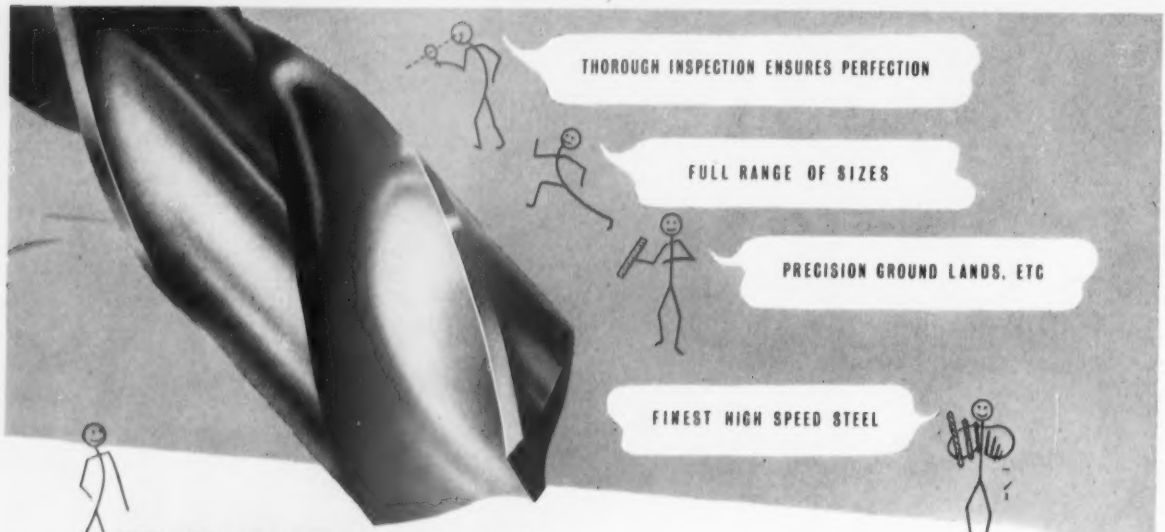


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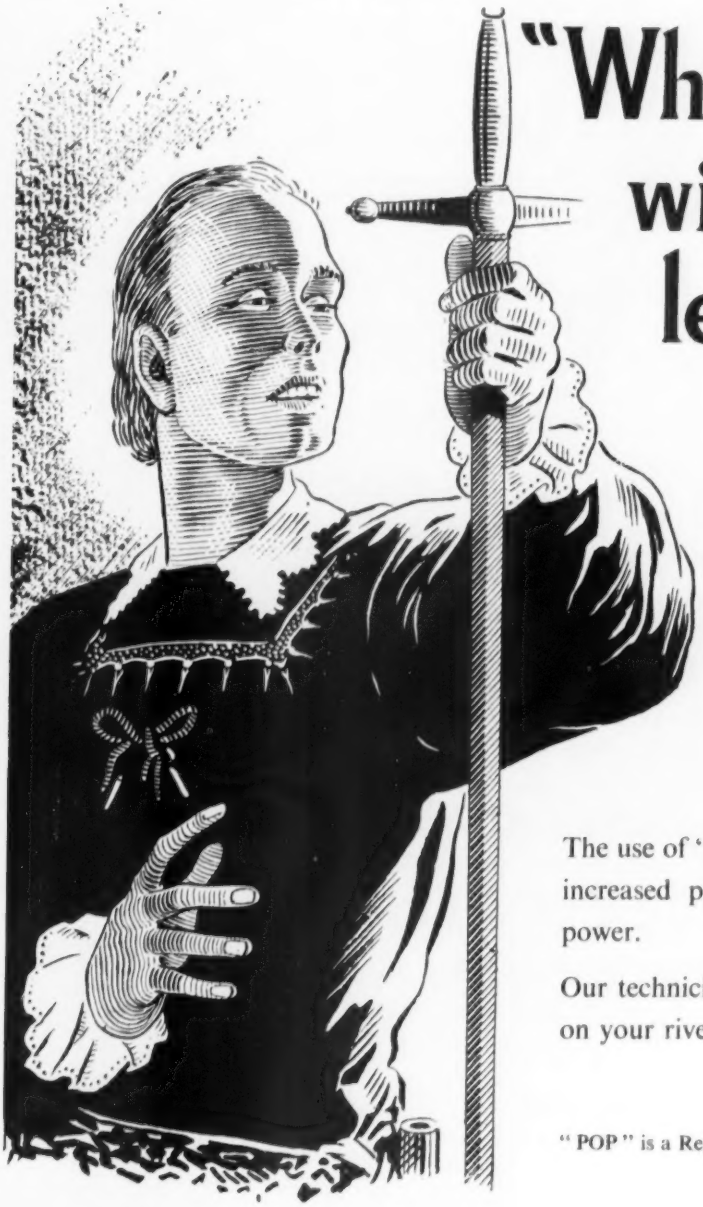
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Having more material things to deal with than Hamlet we lead you to the most efficient riveting system there is—the "POP" Riveting system. Riveting is done by one operator in one operation working from one side of the material only.

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THE MODERN SYSTEM OF RIVETING



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MAS Automatic Die Sinker

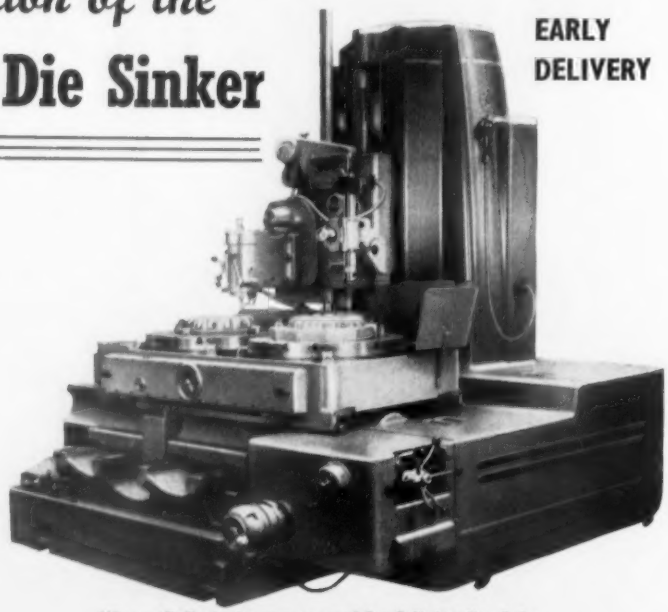
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With two 27½ in. Dia. Rotary Tables, Two Angle Plates and Two Milling Spindles for the simultaneous reproduction of 2 components.

Illustration shows machine fitted with Vertical Attachment.

CAPACITY	
Table, 2 Rotary Tables	27½ in. dia.
Longitudinal Table Traverse (automatic)	39½ in.
Transverse movement of slide ...	15½ in.
Vertical travel of spindle head	31½ in.
Spindle Speeds (8)	70 to 800 or 335 to 3,600 r.p.m.
Feeds (8)	
Longitudinal Table Feed (per min.) ...	¼ in. to 8½ in.
Spindle Vertical Feed (per min.) ...	¼ in. to 5½ in.
Net weight approx.	9½ tons



We cordially invite you to send for full details of the MAS FK 08c DIE SINKER.

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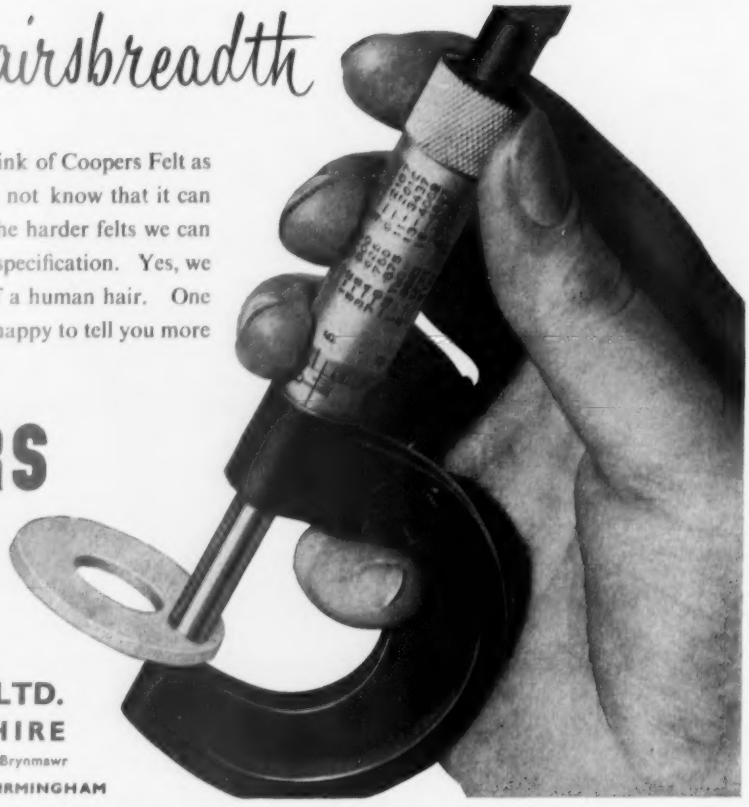
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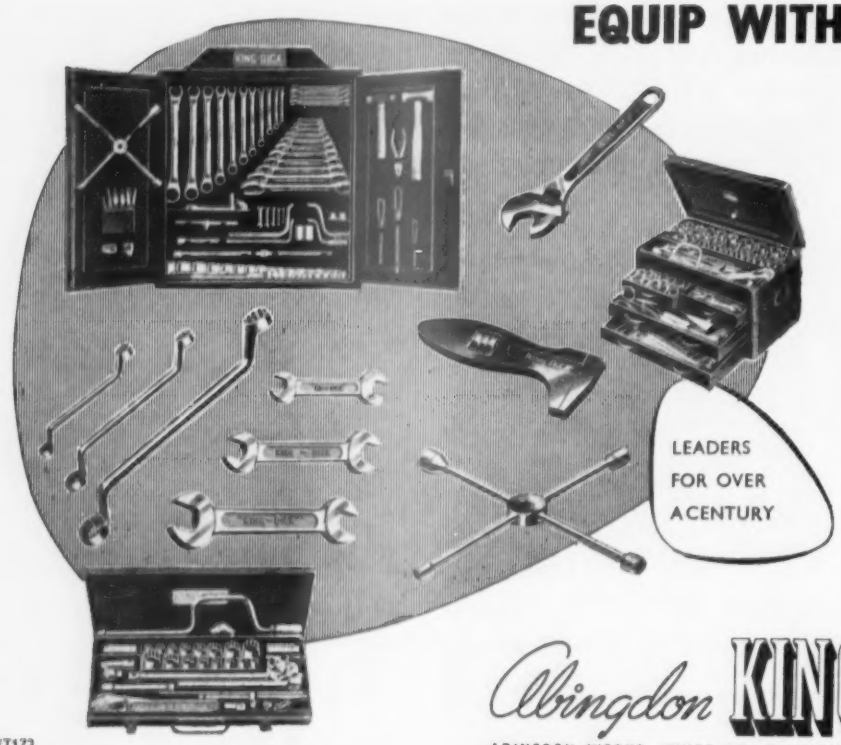


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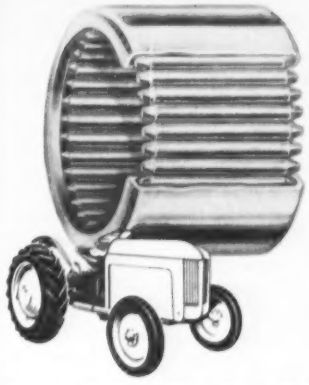
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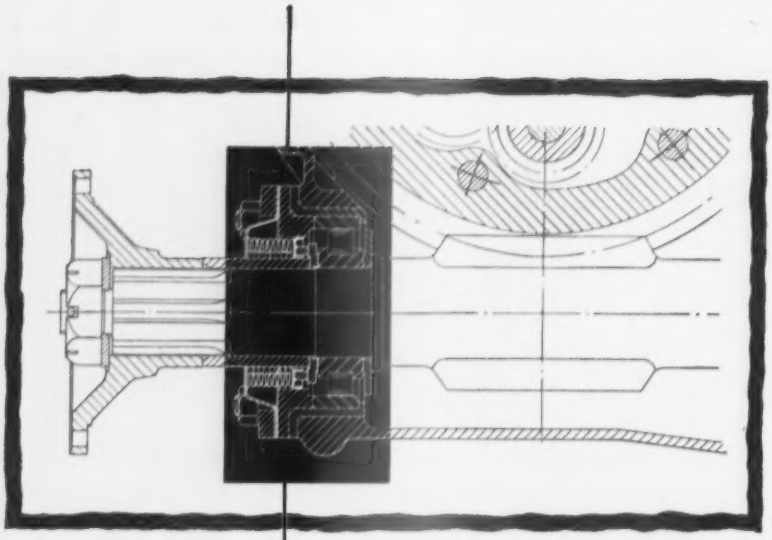
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As cylinders wear, oil gets up past the rings into the combustion chambers. That means that it burns away and you find yourself buying far more oil than you did. But that's not all. The gap between cylinder walls and pistons allows the explosive gases to leak down past the piston. Your engine loses power, your plugs oil up and you waste petrol too.

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3 The rails 'wipe' oil from cylinder walls, avoid scraping and wear.

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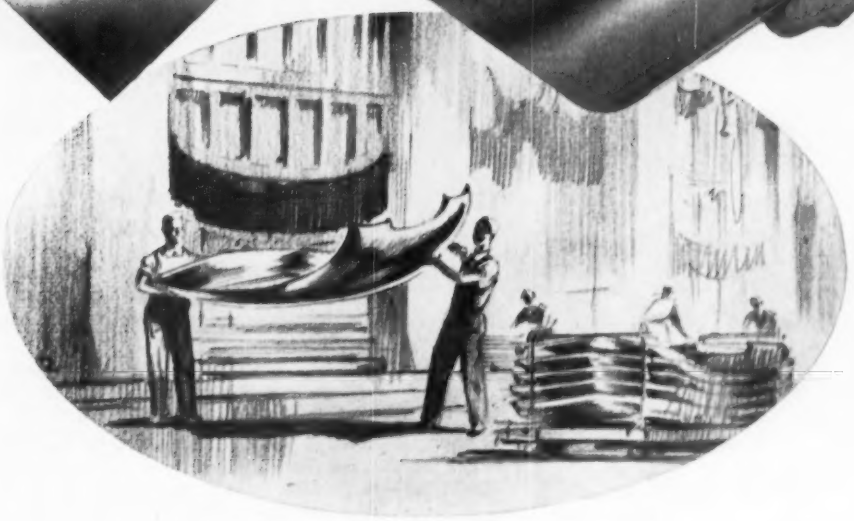
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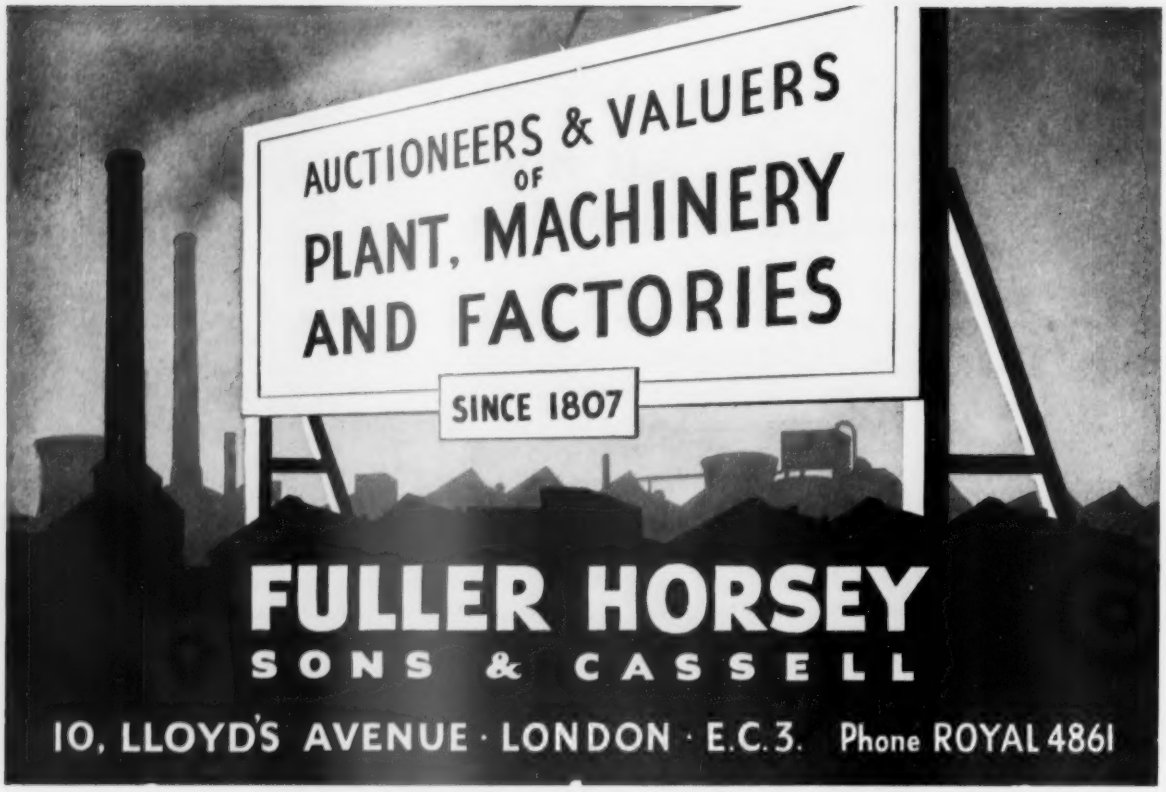
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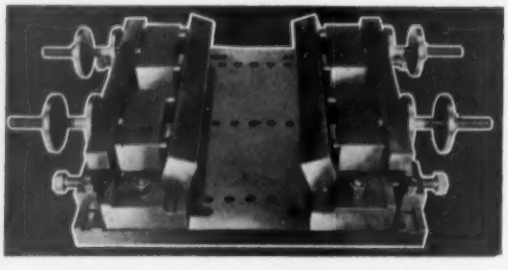
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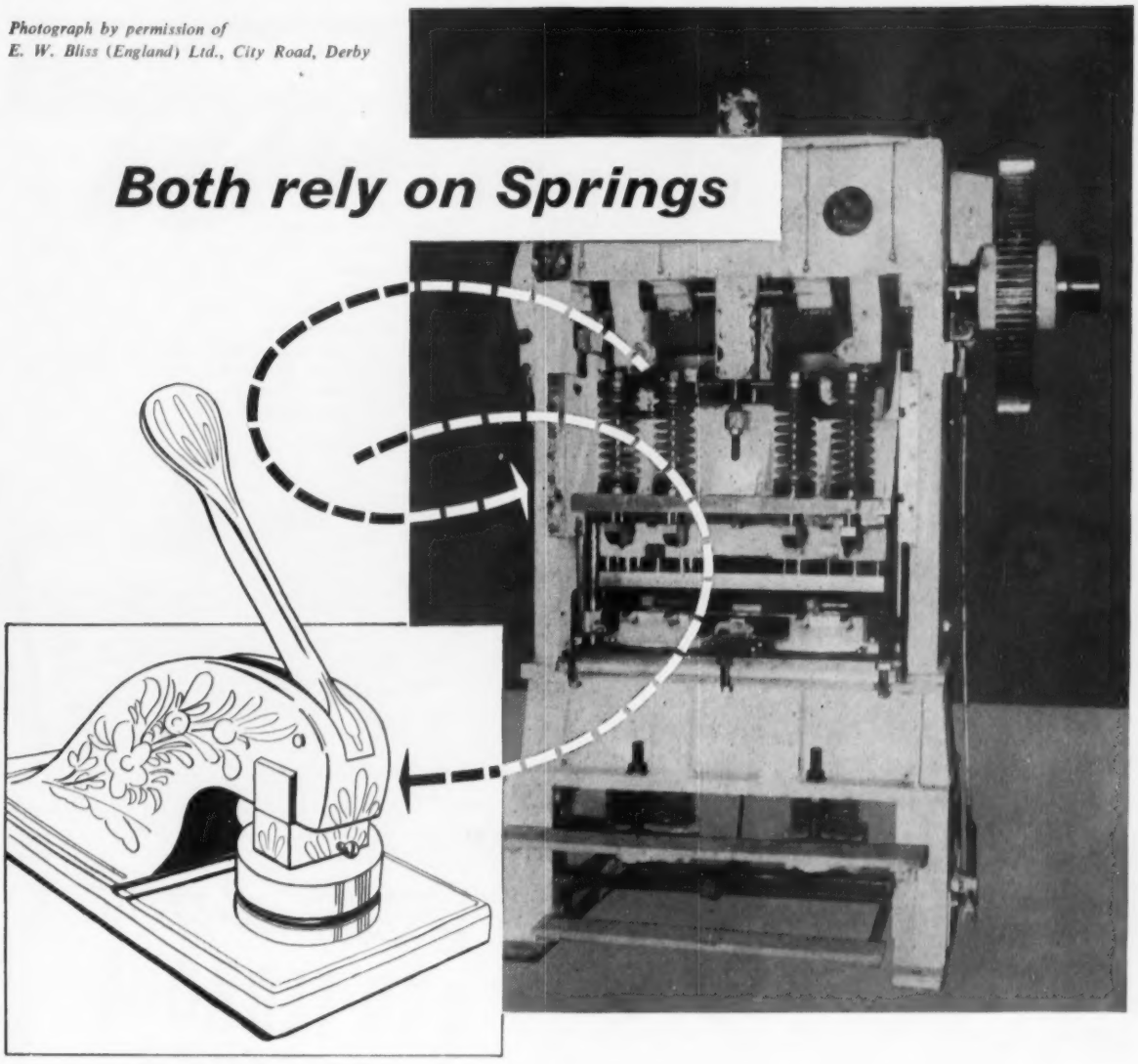


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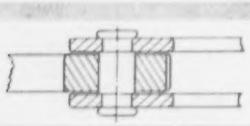
Another problem

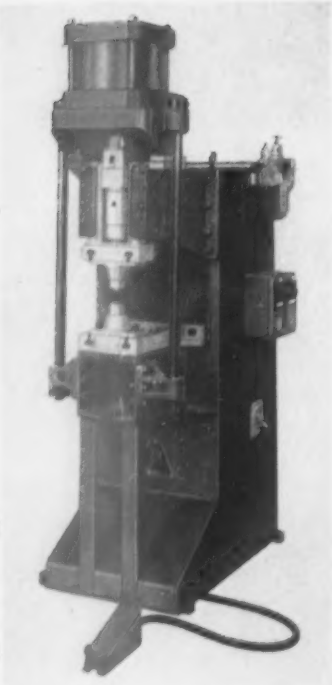
Problem:
To heat and close link rivets—diameter 11/16ths and 7/8ths—of conveyor chain.

Data:
Conveyor chain links — two outer, one inner—and double-shouldered pins, all of carbon steel.

Production rate achieved: 420 per hour.

The diagram illustrates completed operation.





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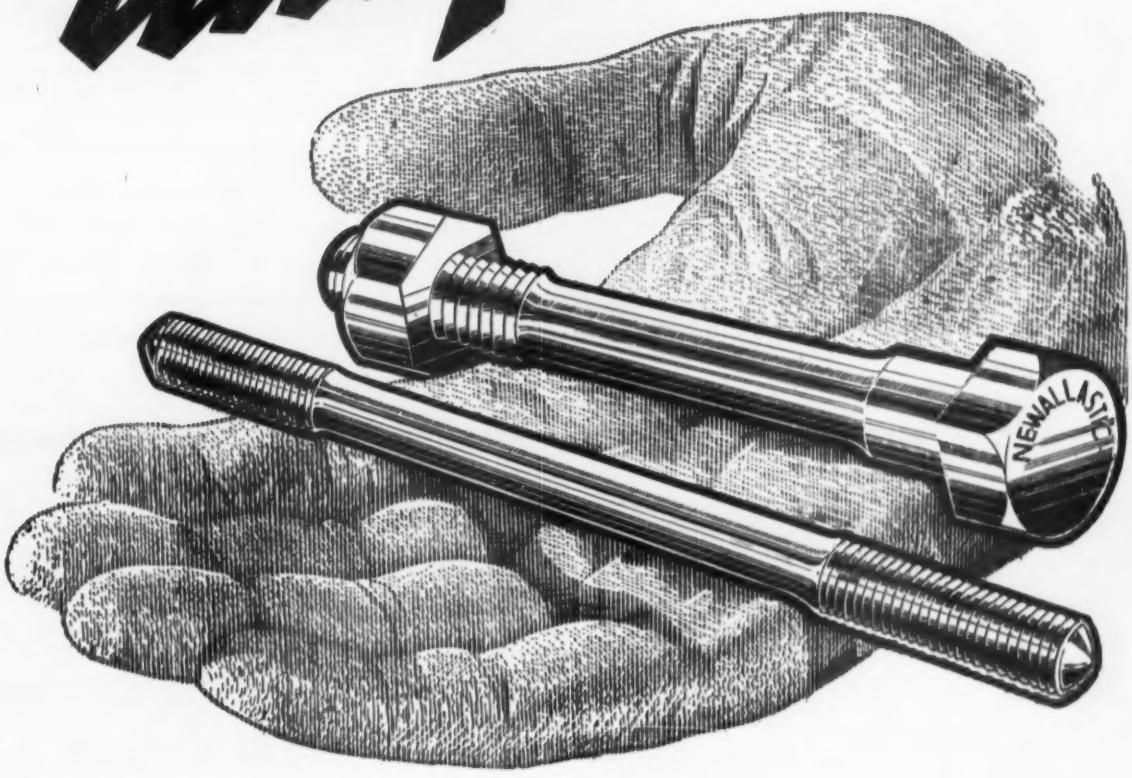
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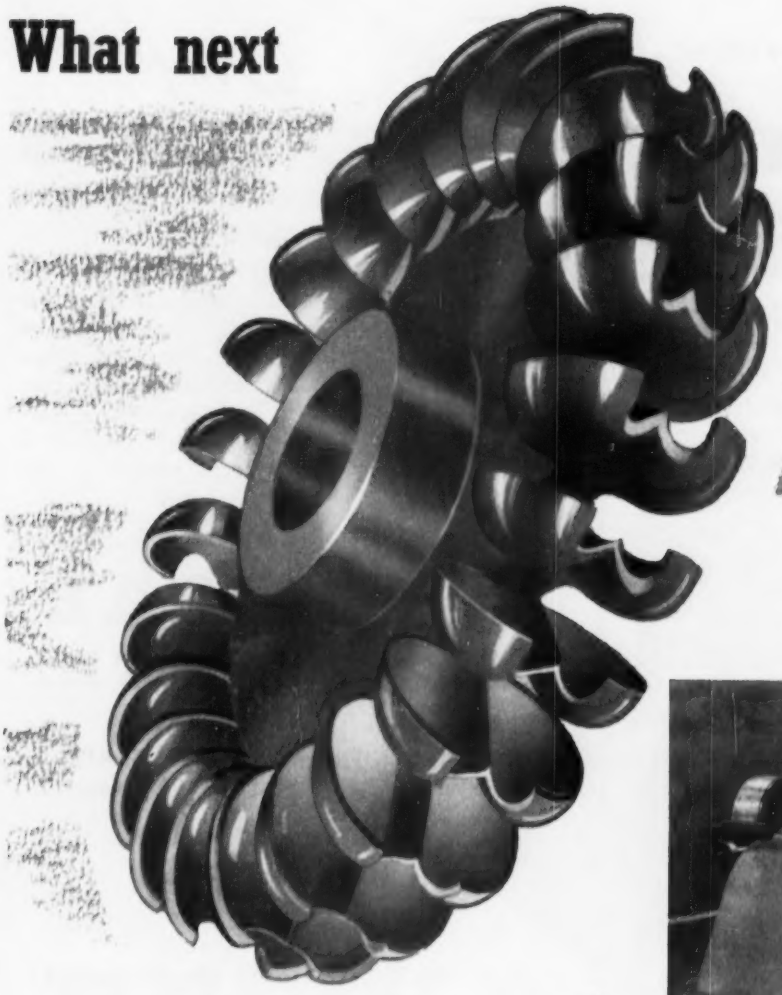
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W.633

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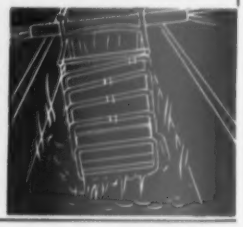
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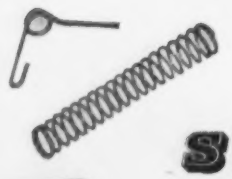
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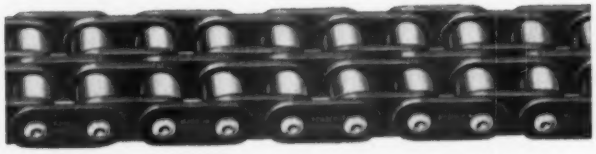
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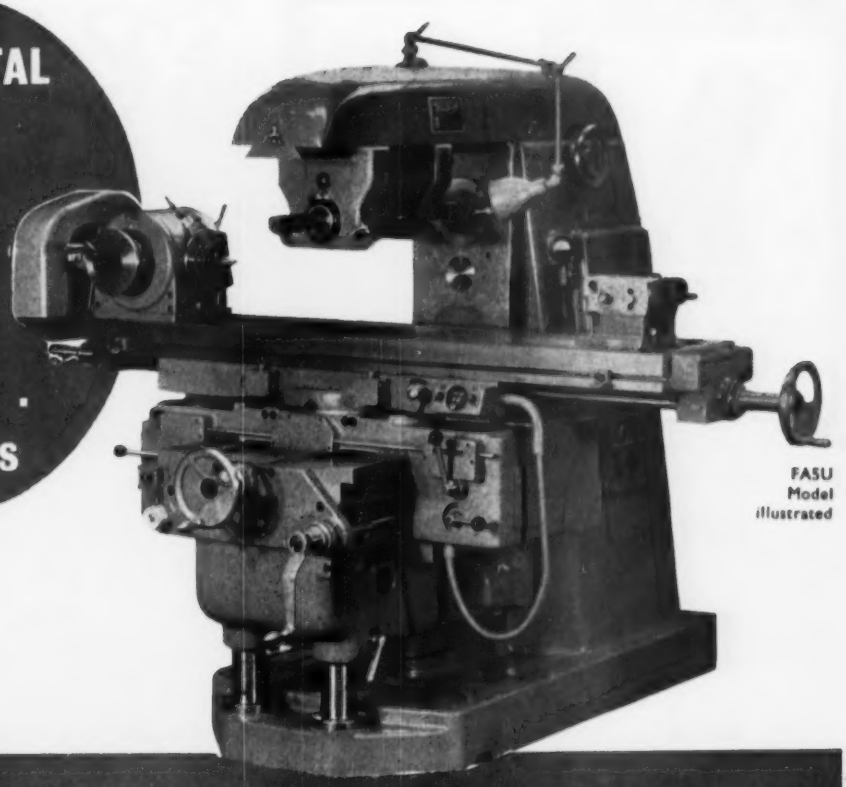
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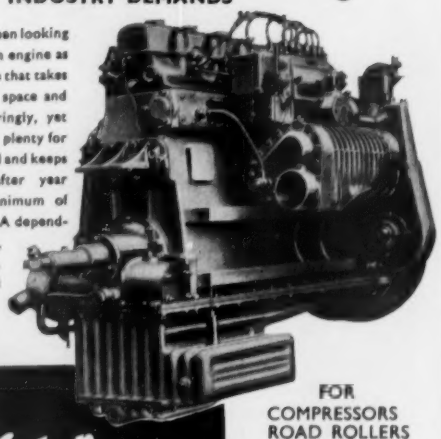
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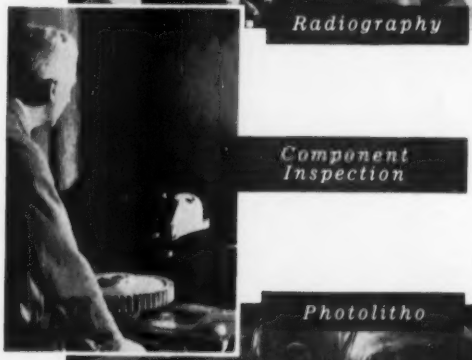
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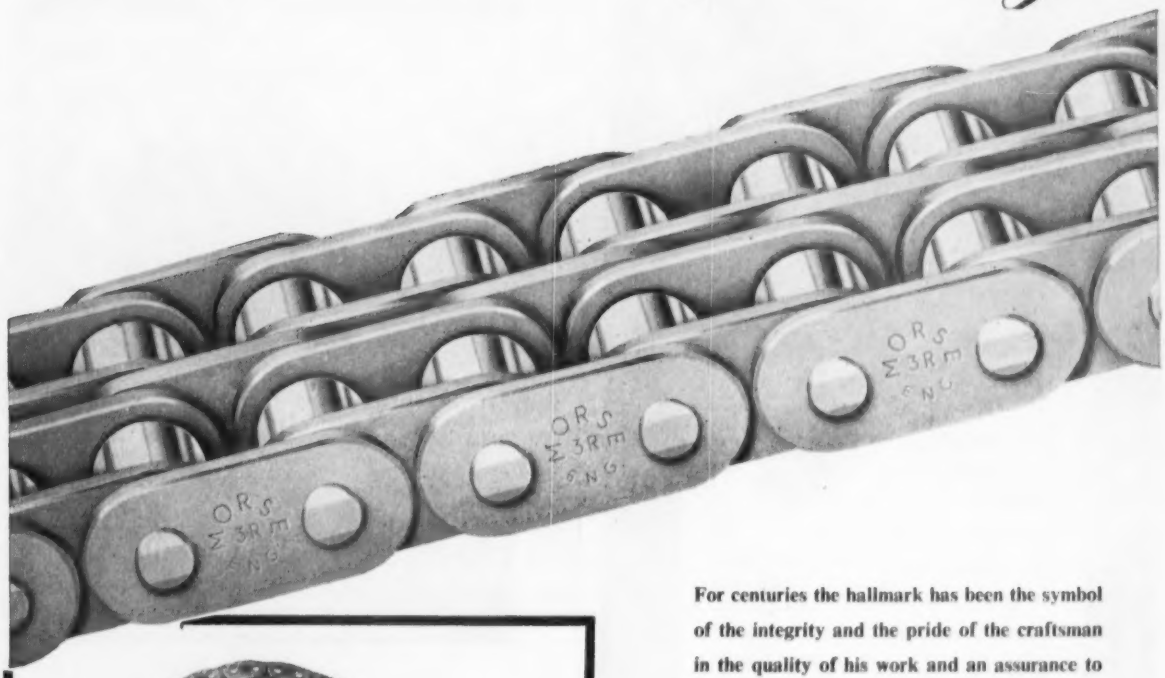


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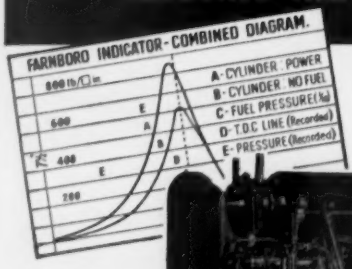
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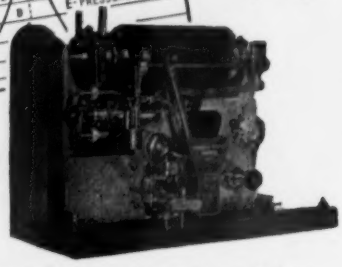
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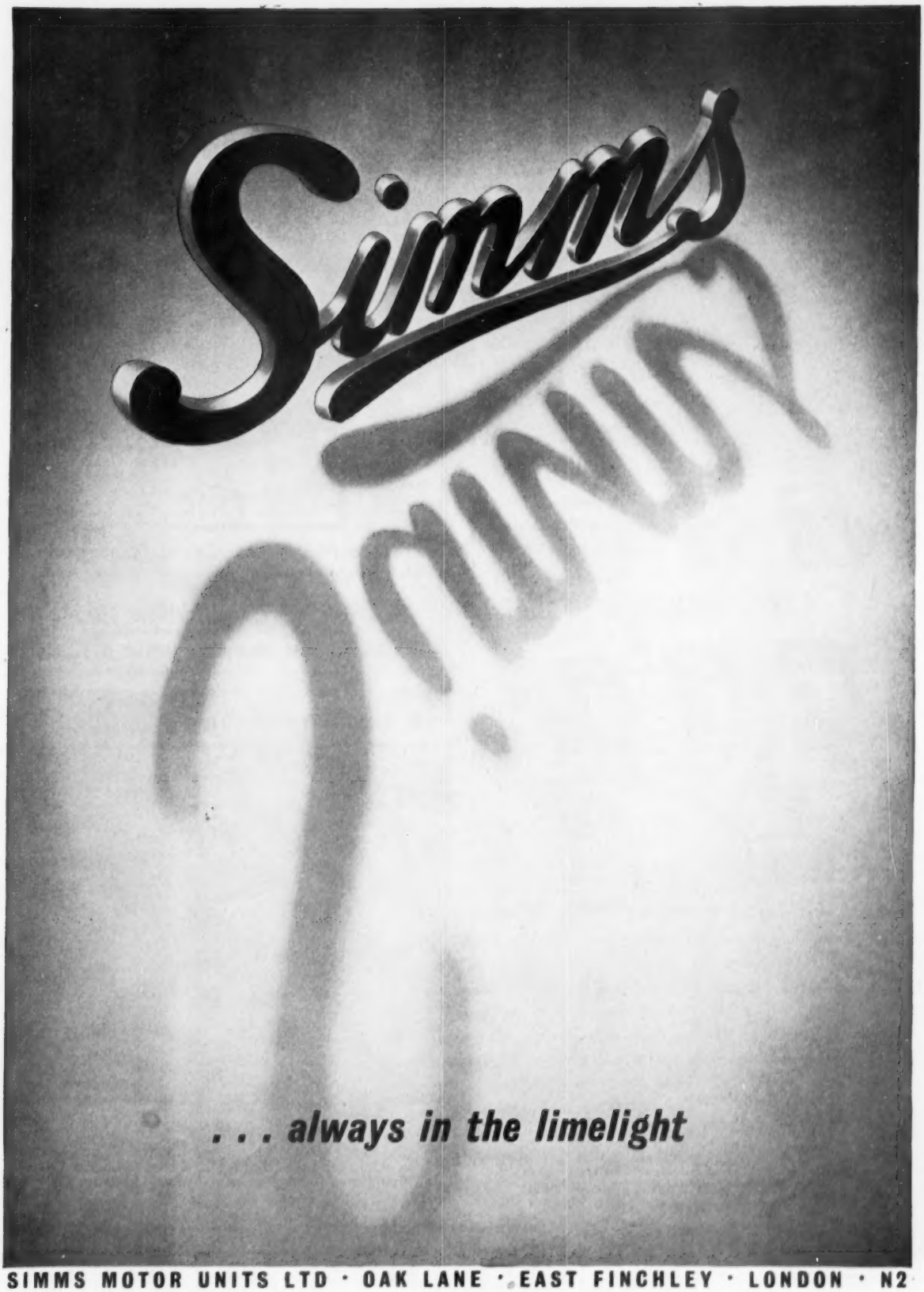
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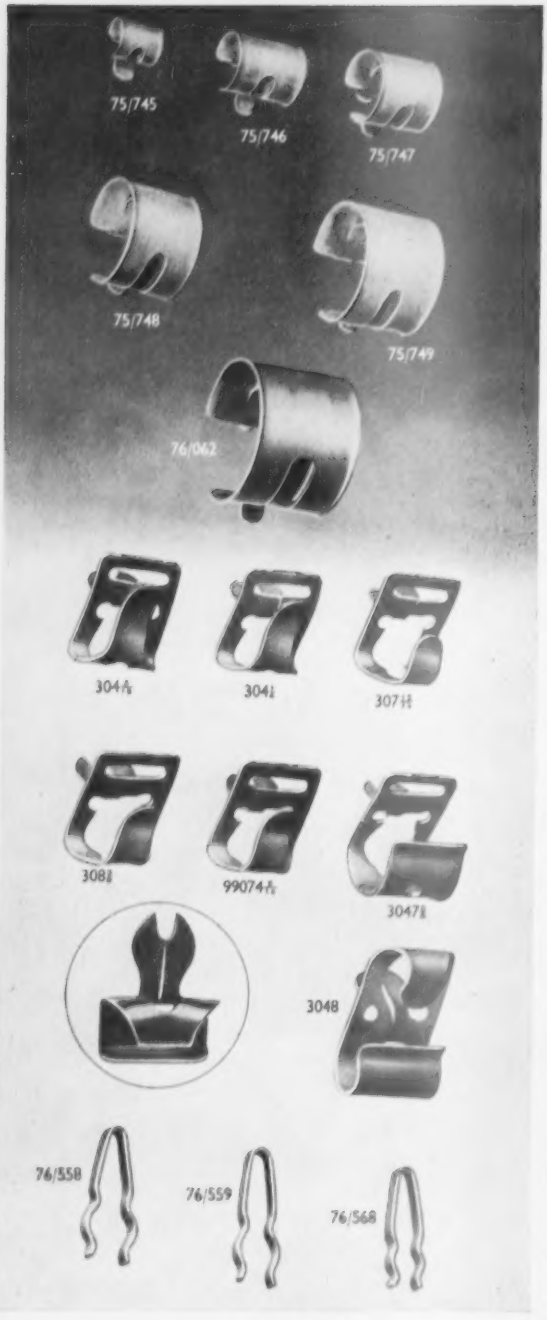
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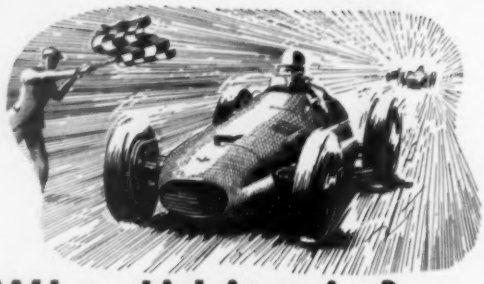
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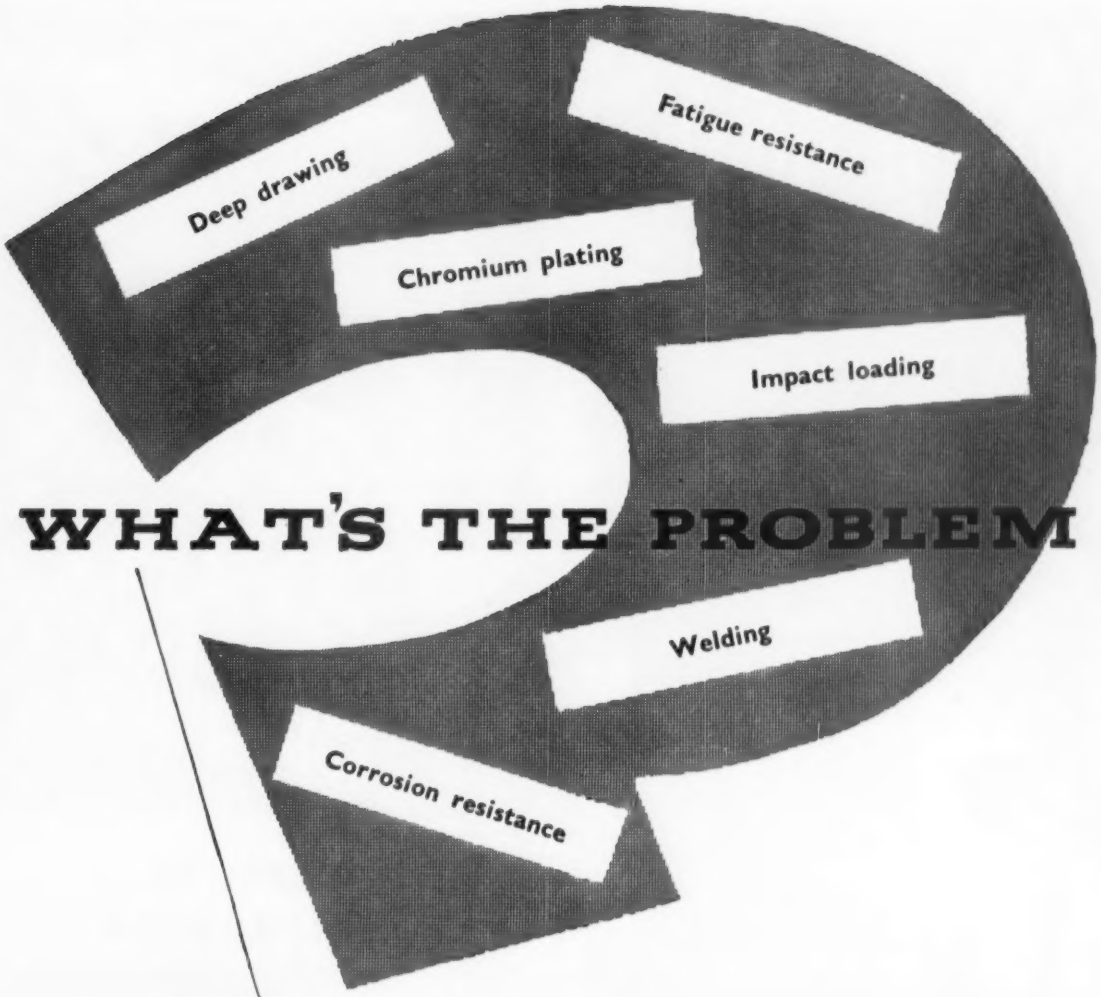
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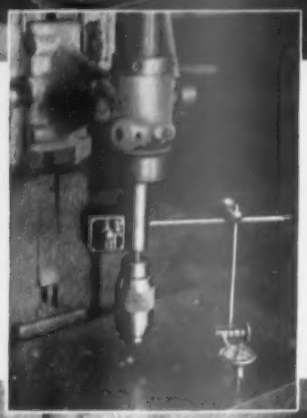
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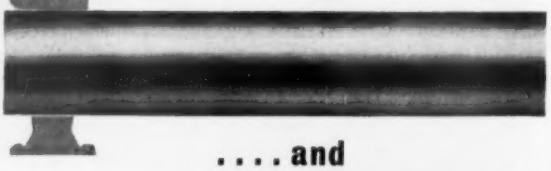




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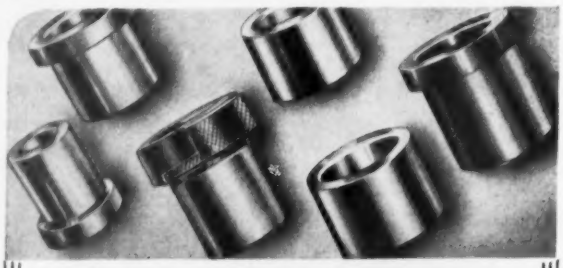
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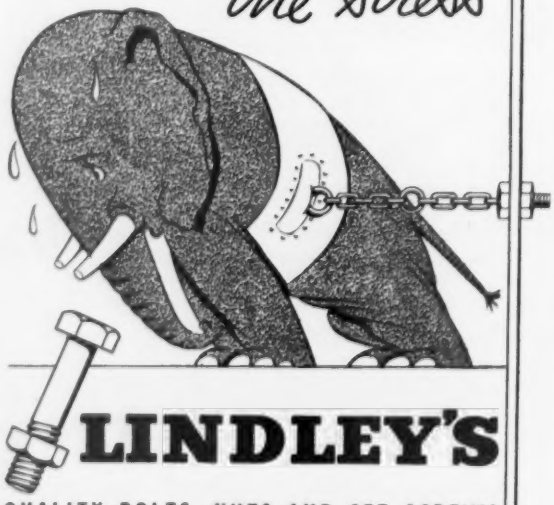
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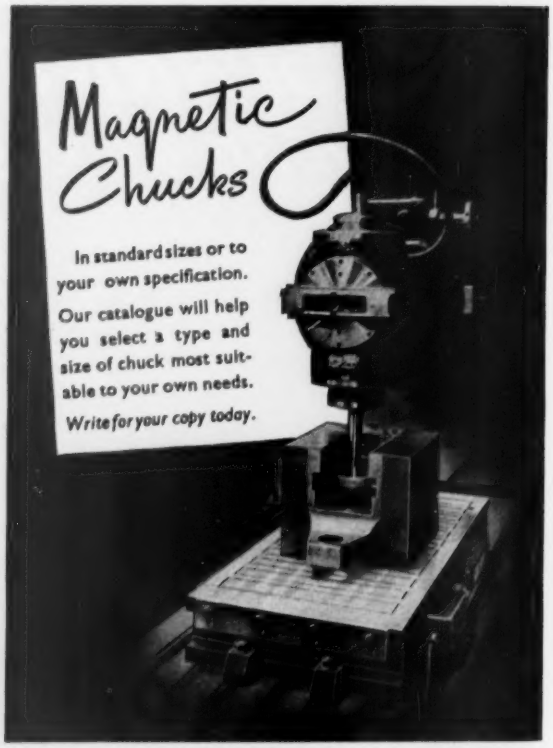
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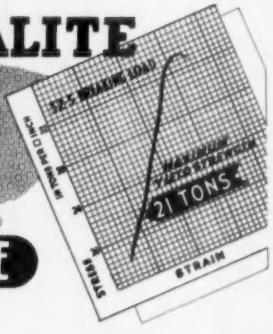
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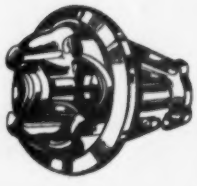
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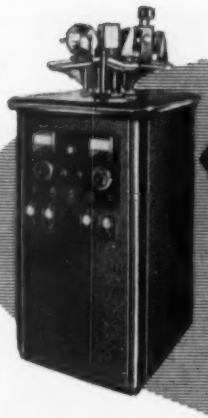


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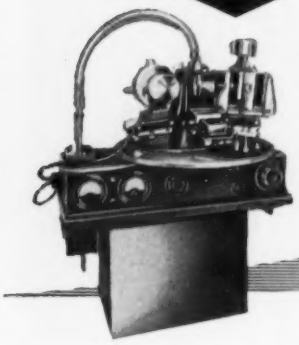


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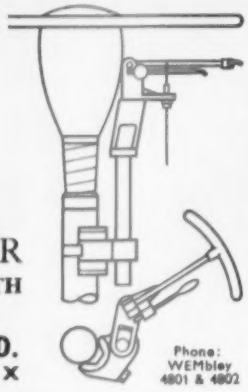
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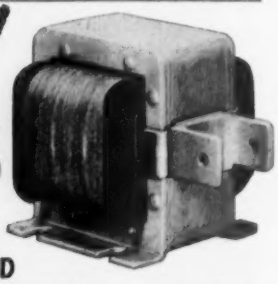


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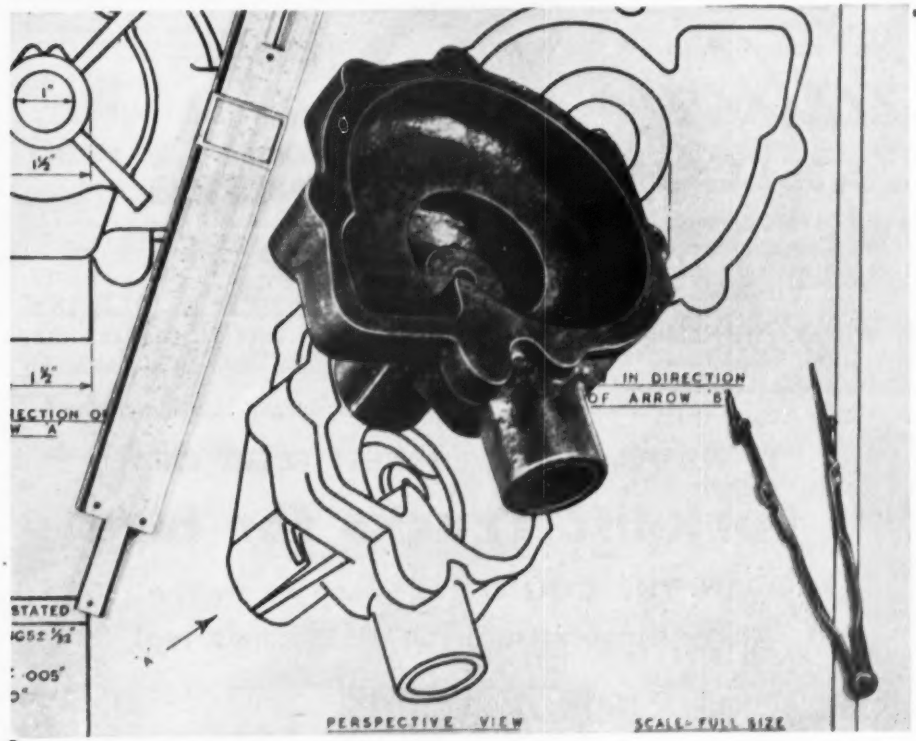
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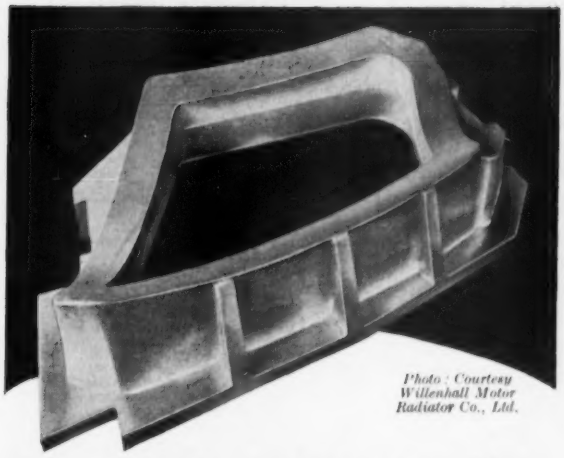


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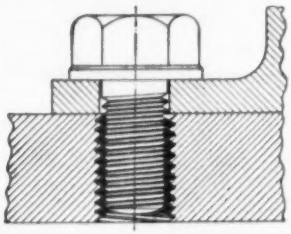
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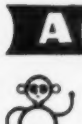
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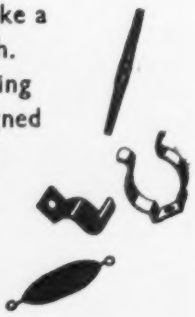
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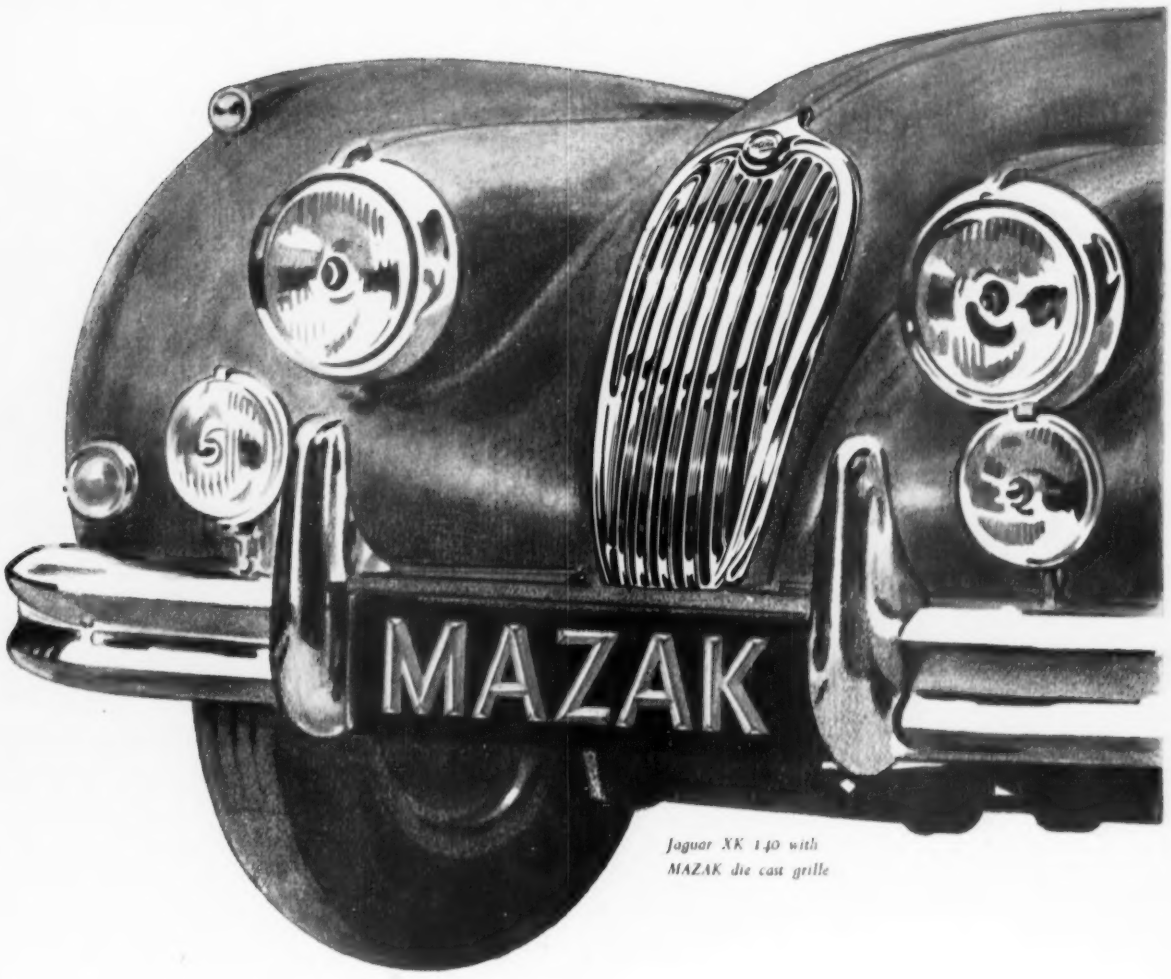
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